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Division of Commercial Fisheries
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Bristol Bay Sockeye Salmon Smolt Studies for 1987

by

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and

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State of Alaska

Steve Cowper, Governor

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ABSTRACT

Numbers of sockeye salmon (*Oncorhynchus nerka*) smolt migrating to sea from five rivers in Bristol Bay, Alaska, in 1987 were estimated from sonar counts and age-weight-length (AWL) samples. Hydroacoustic equipment was used to estimate total smolt biomass, while AWL samples were used to convert biomass estimates to numbers of juveniles by age. Total numbers of smolt migrating from each river were 342,686,918 from Kvichak River; 49,868,710 from Egegik River; 26,947,225 from Ugashik River; 36,227,371 from Wood River; and 7,775,860 from Nuyakuk River. Most smolt migrating from the Kvichak (96.7%), Egegik (91.0%) and Ugashik (79.7%) Rivers were age II, (the progeny of 1984 spawners). Most smolt migrating from the Wood (92.0%) and Nuyakuk Rivers, (93.6%) were age I (the progeny of 1985 spawners).

KEY WORDS: Smolt, juvenile sockeye salmon, *Oncorhynchus nerka*, juvenile migration, sonar, Bristol Bay, Kvichak River, Egegik River, Ugashik River, Wood River, Nuyakuk River

INTRODUCTION

The Bristol Bay Management Area, which includes all waters east of a line from Cape Newenham to Cape Menshikof (Figure 1), supports the largest sockeye salmon (*Oncorhynchus nerka*) fishery in the world. The average commercial catch from 1978 through 1987 in Bristol Bay was 21.3 million sockeye salmon. To effectively manage this valuable fishery, managers need accurate abundance forecasts for returning adults and information on optimal spawning escapement goals. Estimates of smolt numbers are used to determine freshwater production, which, in turn, should provide better descriptions of return-per-spawner relationships, improve the accuracy of preseason forecasts, and aid in setting goals for optimal numbers of spawners.

Fyke nets were used to estimate smolt numbers on the Kvichak River from 1956 to 1970, on the Naknek River from 1956 to 1978, on the Egegik River in 1957, 1969, and 1978, on the Ugashik River from 1955 to 1965, 1967 to 1970, and 1972 to 1975, and on the Wood River from 1951 to 1966 (see Kerns 1961; Rietze and Spangler 1958; Jaenicke 1968; Pella and Jaenicke 1978; Burgner and Koo 1954; Burgner 1962). Fyke net sampling provided information on age, size and relative abundance of smolt but did not accurately estimate total numbers of smolt. To improve estimates of smolt numbers, hydroacoustic equipment developed by Bendix Corporation was tested on the Kvichak River in 1969 (McCurdy and Paulus 1972; Paulus and Parker 1974). Further testing of and modifications to this prototype resulted in construction of smolt counters for use on the Wood (Krasnowski 1976) and Kvichak Rivers (Randall 1977) in 1975 and 1976.

Smolt sonar was tested on the Ugashik River from 1973 through 1975 (Schroeder 1974b and 1975; and Sanders 1976). From 1975 through 1982, smolt studies on the Naknek, Egegik, Ugashik, and Nuyakuk Rivers were limited to occasional fyke net sampling to obtain age and size data (Huttunen 1980; Eggers 1984; Minard 1984). An experimental, two-array sonar system, similar to the one used on the Kvichak River, was tested on the Egegik River during 1981 (Bue 1982).

Smolt enumeration projects using modified counters were started on the Naknek and Egegik Rivers in 1982 (Huttunen 1984; Bue 1984), and the Ugashik and Nuyakuk Rivers in 1983 (Fried et al. 1987; Minard and Frederickson 1987). The migration of smolt from the Naknek River has not been monitored since 1986.

Smolt studies were conducted on the Kvichak, Egegik, Ugashik, Wood, and Nuyakuk Rivers in 1987 to (1) estimate numbers of seaward migrating sockeye salmon smolt, (2) describe smolt migration patterns, (3) collect age, weight, and length data for smolts, and (4) record climatological and hydrological parameters that may affect migratory behavior.

METHODS

Hydroacoustic Equipment

Bendix Corporation constructed all hydroacoustic systems used to estimate smolt numbers in Bristol Bay river systems. Transducers were housed in 3.03-m long

arrays, which were set on the river bottom and connected by coaxial cable to a control unit located in a canvas wall tent on shore. Transducer arrays used on the Egegik, Ugashik, Wood, and Nuyakuk Rivers housed 10 upward-facing transducers. Arrays used on the Kvichak River held seven upward-facing transducers and seven downstream-facing transducers. Arrays were placed in similar locations to previous years and were retrieved at the end of the season.

Hydroacoustic systems were factory calibrated to record one count for a specified amount of fish biomass passing through each transducer beam during a given period. In the Kvichak River one count equalled 83.0 g of biomass, while in all other rivers one count equalled 41.5 g of biomass. Individual arrays were ranged independently, which allowed the operator to set the counting range as near the surface as possible. Each control unit had a disable switch so the person monitoring the equipment could manually stop tabulation of known false counts (i.e., counts due to floating debris, ice, entrained air from high winds or rain, etc.). The control unit automatically recorded and stored the length of time the system was disabled. The control unit provided manual settings for adjusting printing times for accumulated counts (Kvichak counter only 3.75-, 7.5-, 15-, 30-, or 60-min intervals), transducer pulse rate, and the portion of the water column monitored. Transducer signals could be visually observed by connecting an oscilloscope to the unit. All smolt counters, except for the Wood River counter, were designed to monitor three arrays of transducers. The Wood River unit was designed to handle two arrays. An additional switching box was added to the Wood River system to allow for manual multiplexing of four arrays.

Project Locations

The counting site on the Kvichak River was located 5 km below the outlet of Lake Iliamna (Figure 1). Three transducer arrays, referred to as inshore, center, and offshore, were anchored 22 m, 40 m, and 59 m from the east bank. The counting site on the Egegik River was located 4 km below the outlet of Becharof Lake. The inshore, center, and offshore arrays were anchored 40 m, 55 m, and 67 m from the south bank. The counting site on the Ugashik River was located 50 m below the outlet of Lower Ugashik Lake. Due to the narrow width of the channel, only two arrays were used. The inshore and offshore arrays were anchored 14 m and 20 m from the north bank. The counting site on Wood River was located 1 km below the outlet of Lake Aleknagik. Four transducer arrays (I, II, III, and IV) were anchored 20 m, 31 m, 46 m, and 61 m from the north bank. The counting site on the Nuyakuk River was located 3.5 km below the outlet of Tikchik Lake. The inshore, center, and offshore arrays were anchored 30 m, 53 m, and 67 m from the south bank.

Estimation Of Smolt Numbers

The process of estimating smolt numbers was divided into three major steps: (1) determining total fish biomass migrating past the study site; (2) sampling the migrating fish population to estimate species, age, weight, and length composition; and (3) converting fish biomass into numbers of smolt by age and species based on estimated population parameters.

Biomass Estimation

Fish biomass was estimated with continually monitored hydroacoustic equipment. Most smolt migrate in the upper portion of the water column. The counting range was set to record counts within 1-2 cm of the water surface to avoid counting debris or air entrapped on the surface. Sources of false counts such as boats, wind, rain, debris, etc. were recorded in logs and the operator disabled the sonar unit whenever false counts or false count conditions were detected. Known false counts were subtracted from hourly totals and linear interpolations were used to estimate counts missed while the sonar was disabled.

Signal pulse rate of the smolt counter was set to correspond with the river velocity measured over one array (referred to as the velocity index array). Because velocities of Egegik and Wood Rivers are influenced by tides, a Marsh-McBirney current meter was anchored directly behind the velocity index array to continuously monitor river velocities. The smolt counters at Egegik and Wood Rivers were adjusted every 15-30 min to account for changes in river velocity. A Marsh-McBirney meter was also used to monitor river velocities over the Nuyakuk River index array, and the signal pulse rate of the counter was adjusted daily at 1200 hours. Velocities of Kvichak and Ugashik Rivers are more stable than the other rivers. Thus river velocities at these sites were measured periodically with a Gurley current meter, and the counters were adjusted accordingly. To account for differences in river velocities between the index array and the remaining arrays, current readings over each array were taken at specified intervals and velocity correction factors, vcf_i, were then calculated:

$$vcf_i = \frac{v_i}{v_{index}} \quad , \tag{1}$$

where:

vcf_i = velocity correction factor for array i;

v_i = velocity over array i;

v_{index} = velocity over the velocity index array.

Using these correction factors, adjustments for differences in river velocities were made to daily counts for each array:

$$ac_{i,z} = c_{i,z}\, vcf_i \quad , \tag{2}$$

where:

$ac_{i,z}$ = adjusted counts for array i on day z;

$c_{i,z}$ = counts for array i on day z.

All sonar arrays, except those at Wood River, were used to monitor fish biomass 24 h per day, so daily counts for each array represented actual counts registered by the sonar unit. The counter at Wood River was designed to control only two of the four arrays used. Array I (referred to as the index array) was continuously monitored by the unit. The other three arrays (arrays II, III, and IV) were each monitored for 15-min periods each hour. The sequence of monitoring arrays for the first hour was: array I and II for 15 minutes, array I and III for 15 minutes, array I and IV for 15 minutes, and array I and II for 15 minutes. For subsequent hours, this pattern would be continued: array I and III for 15 minutes, array I and IV for 15 minutes, array I and II for 15 minutes, array I and III for 15 minutes, and so forth. Consequently, total daily counts for array I were known, while those for arrays II, III, and IV were estimated:

$$\hat{hc}_{i,z,k} = \sum_{l=1}^{p} \left(pc_{i,z,k,l} \frac{4}{p} \right) , \tag{3}$$

where:

$\hat{hc}_{i,z,k}$ = estimated counts for array i, day z, and hour k;

$pc_{i,z,k,l}$ = sonar counts for array i, day z, hour k, and counting period l;

p = the number of 15-min periods that array i was monitored during hour k and day z.

If an array was not monitored during an hour, counts were linearly interpolated using estimated counts from the previous and following hours. Estimated $\hat{c}_{i,z}$ for Wood River was used in equation 2.

$$\hat{c}_{i,z} = \sum_{l=1}^{24} \hat{hc}_{i,z,k} , \tag{4}$$

where:

$\hat{c}_{i,z}$ = estimated counts for array i on day z.

The width of river monitored by each array depended on array length (3.03 m), water depth over the array, and transducer signal beam width:

$$l_{i,z} = 3.03 + 2 \left(d_{i,z} \tan \frac{bw}{2} \right) , \tag{5}$$

where:

$l_{i,z}$ = width of river monitored by array i on day z;

$d_{i,z}$ = water depth over array i on day z;

bw = transducer beam width, in degrees (18° for Kvichak transducers; 9° for transducers at all other rivers).

Arrays were placed perpendicular to the river current, at locations similar to those in previous years. Distances from each array to a reference point on one of the river banks were measured with a marked length of line. A separate hydroacoustic system, using a single side scanning transducer aimed across the river, was used at Kvichak, Wood and Nuyakuk Rivers to determine the lateral distribution of smolt across the river. Estimates of the inshore and offshore migrational limits of smolt for the other rivers were taken from previous years side scanning sonar data. At sites where three arrays were used, distances between the following locations were calculated: (1) inshore limit of smolt passage to first array (D_1); (2) first to second array (D_2); (3) second to third array (D_3); (4) third array to offshore limit of smolt passage (D_4).

The biomass of fish passing the counting site was estimated as follows:

$$\hat{B}_z = \frac{1}{2} D_1 \left(\frac{ac_{1,z}}{l_{1,z}}\right) + \sum_{i=1}^{na-1} \frac{1}{2} D_i \left(\frac{ac_{i,z}}{l_{i,z}} + \frac{ac_{i+1,z}}{l_{i+1,z}}\right) + \frac{1}{2} D_{na+1} \left(\frac{ac_{na,z}}{l_{na,z}}\right) , \quad (6)$$

where:

$\hat{B}_z$ = estimated biomass on day z;

D_i = the distance for interval i;

na = number of transducer arrays used.

Age, Weight, Length Estimation

Data on age, weight, and length were obtained from samples of smolt captured in fyke nets. Smolt weight (g) and length (mm from tip of snout to fork of tail) were measured, while age was determined from scales mounted on glass slides which were read using a microfiche reader. Smolt were designated as age I, age II, or age III depending on the number of freshwater annuli. Parent year escapements responsible for smolt outmigrating in 1987 were 1985 for age-I smolt, 1984 for age-II smolt, and 1983 for age-III smolt.

The goals for sample sizes for the Kvichak, Egegik, and Ugashik Rivers were set at a minimum of 400 smolt per day. Based on binomial proportions, a sample of 400 smolt per day was necessary to estimate on a daily basis the true percentages of the two age groups within 5 percentage points 95% of the time (Goodman 1965, Cochran 1977). Whenever daily samples of 400 smolt were not obtained, samples from subsequent days were combined until a total of at least 400 was reached. Because mean length, which is strongly correlated with age, has differed among individual fyke net samples within a day (Minard and Brandt 1986), attempts were made to obtain 100 smolt from six different fyke net catches each day to ensure that age composition estimates were representative of the population migrating past the sonar site. Because the weight and age of smolt are strongly correlated to length and to reduce the time and cost of data collection, all smolt collected each day were measured for length (up to a maximum of 600), while only 100 smolt were weighed and aged.

Age-I smolt are dominant each year in the migration from the Wood and Nuyakuk Rivers; consequently, sample goals were lower. Three samples of 100 smolt were collected daily (300 smolt per day) from the Nuyakuk River. Based on binomial proportions, a sample of 300 smolt per day would estimate on a daily basis the true percentages of the two age groups within 5 percentage points 90% of the time (Goodman 1965, Cochran 1977). Of the 300 smolt captured daily at Nuyakuk River, lengths were measured for all smolt, while only 100 smolt were weighed and aged. Smolt migration patterns for Wood River made it difficult to consistently collect large numbers of smolt. The sample size goal for Wood River was set at 120 smolt per day. Samples were pooled for subsequent days until at least 200 smolt were in the pooled sample. All 120 smolt were measured for length, weight, and age.

Weight was estimated for smolt measured only for length based on paired weight-length data obtained from smolt sampled for all three parameters (Ricker 1975):

$$W_j = a \ L_j^b \quad , \tag{7}$$

where:

W_j = weight of an age j smolt;

L_j = fork length of an age j smolt.

Age was estimated for smolt measured only for length based on an age-length key developed by Bue and Eggers (1989). The age-length key uses length to categorize smolt as either age-I or age-II by determining a critical length (L^*) which minimized classification error (E_i, where i=age). L^* is chosen such that $E_I = E_{II}$, where E_I is the number of smolt classified as age-II, given they are age-I, and E_{II} is the number of smolt classified as age-I given they are age-II.

Because of variability of age and size composition estimates among subsamples (fyke net catches) taken the same day, daily mean weight and age proportions were estimated as the mean of subsampled values:

$$\hat{W} = \frac{\sum_{k=1}^{m} \frac{\Sigma w_k}{n_k}}{m} \quad , \tag{8}$$

where:

$\hat{W}$ = estimated mean weight of smolt during a sample period;

m = number of subsamples collected during a sampling period;

w_k = observed weights from subsample k;

n_k = number of observations in subsample k; and

$$\hat{P}_j = \frac{\sum_{k=1}^{m} \frac{n_{j,k}}{n_k}}{m} \quad , \tag{9}$$

where:

$\hat{P}_j$ = estimated proportion of age j during a sample period;

$n_{j,k}$ = number of observations of age j in subsample k.

Estimation of Smolt Numbers

Numbers of smolt by age were estimated by combining biomass estimates with estimates of age and weight composition. Mean weight of smolt was used to convert estimates of biomass per count into estimates of smolt per count:

$$S\hat{P}C = \frac{BPC}{\hat{W}} \quad , \tag{10}$$

where:

$S\hat{P}C$ = estimated number of smolt per sonar count;

BPC = biomass per count.

The estimated number of smolt was the product of smolt per count and estimated biomass:

$$\hat{N}_z = \hat{B}_z \quad S\hat{P}C \quad , \tag{11}$$

where:

$\hat{N}_z$ = estimated number of smolt in population on day z.

The estimated number of smolt was then apportioned into age classes:

$$\hat{N}_{j,z} = \hat{N}_z \quad \hat{P}_j \quad , \tag{12}$$

where:

$\hat{N}_{j,z}$ = estimated number of smolt of age j on day z.

Finally, daily estimates of smolt numbers were summed to provide season totals:

$$\hat{N}_{tot} = \Sigma \hat{N}_z \quad , \tag{13}$$

where:

$\hat{N}_{tot}$ = estimated total number of smolt which passed the site during the season; and

$$\hat{N}_{j,tot} = \Sigma \hat{N}_{j,z} \quad , \tag{14}$$

where:

$\hat{N}_{j,tot}$ = estimated number of smolt of age j which passed the sonar site during the season.

Climatological Data Collection

A small weather station was maintained at each counting site. Observations on sky conditions, wind direction, wind velocity (km/hr), daily precipitation (mm), air temperature (°C), and water temperature (°C), were recorded at 0800 and 2000 hours daily.

RESULTS

Kvichak River

A total of 5,661,890 sonar counts (1 count = 83 g biomass) were recorded at the Kvichak River smolt site from 21 May through 13 June 1987 (Table 1). Most counts were recorded over the offshore array (53.2%). Few counts were recorded over the

inshore array (17.3%). Daily sonar counts were highest from 24 through 30 May during which time about 58% of the counts were recorded.

Based on side scanning sonar, most smolt migrated within a corridor which was 6.4 m to 74.4 m from the east bank. Once set corresponding to a river velocity of 1.5 m/s, the signal pulse rate of the smolt counter was not changed for the entire season. Velocity correction factors for the inshore, center and offshore arrays, calculated three times during the season, were 0.96, 1.06, 1.06, respectively, on 21 May; 0.96, 1.07, 1.06, respectively, on 29 May; and 0.99, 1.08, 1.08, respectively, on 17 June.

An estimated 342,686,918 smolt migrated from the Kvichak River in 1987 (Table 2). This is the greatest number estimated since the sonar project was begun in 1971. (Previously, the greatest migration was observed in 1981 when an estimated 252,222,768 smolt migrated from the Kvichak River.) Age-II smolt comprised 97% of the 1987 total migration (Table 2). A temporal trend was not evident in the daily age proportions. The estimated numbers of smolt per count ranged from 11.4 to 14.0 during the counting period (Table 3).

Smolts produced by the 1984 spawning escapement of 10,490,670 sockeye salmon were estimated at 39.5 smolt per spawner (83,470,460 age-I smolt migrating to sea in 1986 and 331,384,545 age-II smolt migrating in 1987; Table 4). For brood years 1969 to 1983, average marine survival has been 11.6% for age-I smolt and 13.6% for age-II smolt (brood years 1968 to 1982; Table 5).

A total of 2,180 smolt were sampled for age, length, and weight data (Table 6). Mean lengths of age-I and age-II smolt in 1987 were 82 mm and 96 mm. Mean weights of age-I and age-II smolt in 1987 were 4.5 g and 7.0 g. Mean lengths of age-I and age-II smolt in 1987 were less (nonstatistical comparison = NSC) than the 1955-86 averages of 88 mm and 109 mm. Similarly, average weights of age-I and age-II smolt in 1987 were less than 1955-86 averages of 5.9 g and 10.7 g (Table 7). An additional 13,046 smolt were measured only for length (Table 8).

River and weather conditions were recorded at the sonar site from 20 May through 14 June (Table 9). Sonar operation was not greatly affected by weather conditions in 1987, as neither ice nor wind presented any problems for counting. Mean water temperature during the project was 6.7 °C (ranged from 4.5 to 9.0 °C). The water temperatures during the peak of the outmigration from 24-30 May were 5.2 to 7.1 °C. Mean water temperature during the 1987 smolt migration was warmer (NSC) than the 1963-86 mean water temperature of 5.5 °C (Table 10).

Egegik River

A total of 4,662,348 sonar counts (1 count = 41.5 g biomass) were recorded at the Egegik River sonar site from 19 May through 13 June, 1987 (Table 11). Most counts occurred over the center array (52.6%). Counts were distributed similarly over inshore (20.2%) and offshore (27.2%) arrays. No side scanning sonar data were collected in 1987 or 1986; consequently, lateral smolt distribution data collected in 1985 were used to define the corridor in which most smolt migrated (12.2 m to 85.3 m from the west bank).

River velocity ranged from 0.65 to 0.76 m/s over the center velocity index array. Velocity correction factors, determined four times, for the inshore and offshore arrays were 0.75 and 0.99 on 17 May; 0.90 and 1.0 on 26 May; 0.70 and 0.98 on 1 June; and 0.78 and 1.0 on 10 June.

The final estimate of seaward migrating sockeye salmon smolt was 49,868,710 (Table 12). The smolt population was comprised of 91.0% age-II, 8.8% age-I, and 0.2% age-III smolt. The percentage of age-II smolt decreased throughout the duration of the migration. Consequently, the estimated number of smolt per count increased throughout the duration of the project because age-II smolt are larger than age-I smolt (Table 13).

Smolt production from the 1984 spawning escapement of 1,165,320 sockeye salmon was 51 smolt per spawner. This was similar to 1981 brood year production of 50 smolt per spawner, less than 1980 and 1983 brood year production of 62 and 107 smolt per spawner, and greater than 1982 brood year production of 28 smolt per spawner (Table 14). Average marine survival has been 24.7% for age-I smolt (1980-1983 brood years) and 27.7% for age-II smolt (1979-1982 brood years; Table 15).

Age, weight, and length measurements were collected from 1,953 smolt (Table 16). Mean weights were 11.6 g, 14.1 g, and 18.9 g for age-I, age-II, and age-III smolt. Mean lengths were 107 mm, 114 mm, and 128 mm for age-I, age-II, and age-III smolt. Age-I sockeye salmon smolt were larger (NSC) than the historical average, while both age-II and -III were smaller (NSC) (Table 17). An additional 9,492 smolt were measured for length (Table 18). After the season, samples were divided into two groups, those collected through 6 June and those collected after 6 June. A separate discriminant function based on length was estimated for age-I and age-II smolt within each group.

Weather and river conditions were recorded at the sonar site during 18 May through 14 June (Table 19). Becharof Lake was virtually free of ice when smolt operations began, thus drifting ice did not pose any problems with counting in 1987. Mean air and water temperatures during the project were 7.4 °C with a range of 1.0 to 16.0 °C and 6.6 °C with a range of 3.9 to 11.0 °C, respectively. Mean water temperature was slightly (NSC) higher than the 1981-86 average of 6.0 °C (Table 20).

Ugashik River

From 17 May to 13 June, 3,299,865 sonar counts (1 count = 41.5 g biomass) were recorded at the Ugashik River sonar site (Table 21). Most counts were recorded over the offshore array (73.6%). Smolt distribution across Ugashik River was not determined with side scanning sonar in 1987, and smolt distribution was assumed to be similar to that observed in 1986 when smolt were found primarily from 7.0 m to 28.3 m offshore of the north bank.

River velocities over the inshore and offshore arrays, measured twice during the season, were 1.6 and 1.5 m/s on 17 May and 1.5 and 1.9 m/s on 14 June. The sonar counter was set at the velocity (1.6 m/s) initially measured over the inshore array. Velocity correction factors used were 1.0 and 0.97 for inshore and offshore arrays from 17-29 May, and 0.96 and 1.18 for inshore and offshore arrays from 30 May through 13 June.

The number of sockeye smolt migrating seaward was estimated to be 26,947,225 (Table 22). Estimated age composition was 20.3% age-I, 79.7% age-II, and <0.1% age-III. Although age-II smolt predominated throughout the migration, they were most abundant during the middle of the season. The percentage of age-II smolt increased from the beginning to the middle of the season, and then decreased towards the end of the counting period. The estimated number of smolt per sonar count ranged from 3.4 to 4.8 (Table 23). Total smolt production from the 1984 brood year was 47.8 smolt per spawner (Table 24). This was less than the production calculated for the 1981 and 1982 brood years (85.9 and 83.7 smolt per spawner), but greater than the production calculated for the 1983 brood year (27.9 smolt per spawner). Marine survival of age-I smolt has ranged from 2% to 13% (1981-83 brood years), while marine survival of age-II smolt ranged from 4% to 33% (1980-82 brood years; Table 25).

A total of 2,190 sockeye salmon smolt were sampled to obtain age, weight, and length information (Table 26). Mean weights of age-I and age-II smolt were 7.9 g and 11.1 g. Mean lengths for age-I and age-II smolt were 94 mm and 107 mm. Age-I smolt were slightly larger (NSC) than the average observed during the previous 21 years of sampling, while age-II smolt were slightly smaller (NSC; Table 27). An additional 10,832 smolt were sampled only for length (Table 28). After the season, samples were divided into two groups: those collected through 5 June and those collected after 5 June. Discriminant functions based on length and weight-length relationships for both age groups were estimated separately for each period.

Climatological and hydrological observations were made at the sonar site from 18 May through 14 June (Table 29). Average air temperature for this time period was 7.2 °C with a range of 2 to 18 °C and average water temperature was 5.9 °C with a range of 4 to 9°C. Average water temperature, 5.9° C, was the same as the average from 1983 through 1986 (Table 30).

Wood River

A total of 889,985 sonar counts (1 count = 41.5 g biomass) were recorded from 23 May through 5 August at the Wood River sonar site (Table 31). The distribution of counts over the four arrays was 30.9% over array I, 32.2% over array II, 20.8% over array III, and 16.0% over array IV. This pattern was similar to that observed in past years (Table 32).

Side scanning sonar data collected in 1987 were not sufficient to describe lateral smolt distribution. Therefore, lateral distribution was assumed to be a function of river width and depth. These parameters were measured and recorded every 5 d during times when tidal influence was minimal. Based on the average of these measurements, smolt were assumed to be distributed throughout a 102 m section of the river extending from 0 m to 102 m from the north bank.

River velocity during the season ranged from 1.46 m/s to 2.01 m/s over the inshore velocity index array. Velocity correction factors used for the remaining three arrays were recalculated 12 times during the season (Table 33).

The final sockeye salmon smolt estimate was 31,377,574 (Table 34). Estimated age composition was 92.6% age-I, 7.4% age-II, and <0.1 age-III smolt. No distinct

temporal trends in the age composition were observed during the season. The estimated number of smolt per sonar count decreased from 7.4 on 23 May to 5.4 on 5 August (Table 35). Total smolt production from the 1984 brood year was 29.7 smolt per spawner (Table 36). Production from the 1973-83 brood years has ranged from a low of 12.3 smolt per spawner (1980 brood year) to a high of 111.8 smolt per spawner (1977 brood year). Average marine survival has been 6.9% for age-I smolt (1973-83 brood years), and 6.2% for age-II smolt (1972-82 brood years; Table 37).

A total of 5,261 sockeye salmon smolt were sampled for age, weight, and length information (Table 38). Mean weights of age-I and age-II smolt were 5.8 g and 8.7 g. Mean lengths of age-I and age-II smolt were 86 mm and 100 mm. Mean length and weight of smolt in 1987 were similar to the 1951-86 means (84 mm and 5.9 g for age-I and 100 mm and 8.6 g for age-II smolt; Table 39). Infection by *Triaenophorus crassus* was greater (NSC) for age-II smolt (57.8%) than for age-I smolt (42.6%; Table 40). The incidence of *T. crassus* has increased (NSC) since 1984 (Table 41).

Weather and river conditions were recorded at the sonar site from 23 May through 5 August (Tables 42-44). Average air temperature for this period was 11.7 °C with a range of 4.5 to 29.5 °C and average water temperature was 6.8 °C with a range of 4.0 to 16.0 °C. This was lower (NSC) than the 1975-86 mean water temperature of 8.4 °C.

Nuyakuk River

From 28 May through 1 July, 158,655 sonar counts (1 count = 41.5 g biomass) were recorded at the Nuyakuk River sonar site (Table 45). Most counts occurred over the center array (40.7%). Counts were distributed similarly over inshore (32.0%) and offshore arrays (27.3%). Nuyakuk River had extreme high water conditions in 1987, causing the river to overflow its banks, which resulted in a large amount of detritus suspended in the water column. The increased level of organic matter in the river produced a large number of false counts (counts caused by debris). These false counts were most prevalent from 12 June through 1 July. The field crew attempted to distinguish smolt counts from false counts by listening to the sonar unit as it registered counts, and by observing returns from the transducer signals on an oscilloscope. Crews monitored each array for smolt counts five times daily, each session lasted approximately 30 min. The proportions of smolt counts by array were averaged for the day and used postseason to adjust daily counts. Sonar counts adjusted for false counts caused by debris totaled 103,667 (65% of the total recorded counts; Appendix A.3). We have little confidence in the accuracy of this adjustment due to the low number of counts observed and the subjective manner in which smolt counts were distinguished from false counts. Therefore, after comparing estimates of smolt migration based on unadjusted sonar counts with those made from adjusted sonar counts, we elected to use the unadjusted counts even though they included some unknown number of false counts.

Side scanning sonar data indicated that most smolt passed the site within a corridor which extended from 14.6 m to 121.6 m from the south bank. River velocity over the inshore array was measured daily at 1200 hours. River velocity measurements taken over the inshore array were used to adjust the smolt counter

and ranged from 0.79 to 1.61 m/s. Velocity correction factors for the center and offshore arrays were determined daily (Table 46).

An estimated 7,775,860 smolt migrated from the Nuyakuk River in 1987 based on unadjusted sonar counts (Table 47). The estimate, based on sonar counts reduced for debris, was 4,835,339 smolt (Appendix A.4). Age-I smolt comprised 93.6% of the 1987 total migration, while age-II smolt made up 6.4% of the migration. Mean weight of smolt decreased through time (NSC); consequently the number of smolt per count increased from 7.4 on 28 May to 10.4 on 1 July (Table 48).

Total smolt production from the 1984 brood year equaled 24.5 smolt per spawner, which is on the low side of the range of 13 to 72 smolt per spawner observed for the 1981-84 brood years (Table 49). Marine survival for age-I smolt for 1981-83 brood years ranged from 3% to 11%, while survival for age-II smolt ranged from 1% to 30% for 1980-82 brood years (Table 50).

Age, weight, and length samples were taken from 1,597 smolt (Table 51). Mean weights were 4.1 g and 6.2 g for age-I and age-II smolt. Mean lengths were 78 mm for age-I and 91 mm for age-II smolt. Age-I and age-II sockeye salmon smolt in 1987 were similar (NSC) in length and weight to the 1978-86 average (Table 52). An additional 2,366 smolt were measured for length (Table 53). After the season, samples were divided into two groups: those collected from 5-14 June, and those collected after 14 June. Discriminant functions based on length and weight-length relationships were estimated separately for age-I and age-II smolt during each sample period (Table 53).

Weather and river conditions were recorded at the Nuyakuk sonar site from 29 May through 2 July (Table 54). Nuyakuk Lake was covered with ice when the sonar project began, and drifting ice interrupted counting for 12 h on 2 June. Mean air and water temperatures during the project were 9.4 °C with a range from 3.9 to 16.7 °C and 4.5 °C with a range from 0.6 to 8.1 °C, respectively.

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Table 1. Sonar counts recorded from three arrays, each with 14 transducers at the sockeye salmon smolt counting site on the Kvichak River, 1987.

	Sonar Counts			
	Transducer Array			
Date[a]	Inshore	Center	Offshore	Total
5 21	75,825	153,770	231,832	461,427
5 22	11,054	14,483	42,221	67,758
5 23	5,517	6,258	14,907	26,682
5 24	107,207	174,206	185,451	466,864
5 25	62,877	130,220	162,594	355,691
5 26	48,773	45,644	74,678	169,095
5 27	90,463	195,216	358,015	643,694
5 28	85,608	260,047	423,846	769,501
5 29	153,879	119,855	225,473	499,207
5 30	82,771	79,051	209,693	371,515
5 31	8,525	17,048	40,365	65,938
6 1	30,920	34,666	46,666	112,252
6 2	33,623	52,463	160,849	246,935
6 3	12,651	14,807	43,520	70,978
6 4	5,268	8,184	16,485	29,937
6 5	23,149	26,677	36,270	86,096
6 6[b]	13,725	32,740	77,916	124,381
6 7	17,590	51,981	172,377	241,948
6 8[b]	13,355	80,987	183,870	278,212
6 9	29,424	52,545	80,238	162,207
6 10	34,515	64,784	108,191	207,490
6 11	10,244	14,011	28,365	52,620
6 12	13,087	25,622	50,032	88,741
6 13	10,568	16,057	36,096	62,721
Total	980,618	1,671,322	3,009,950	5,661,890
Percent	17.32	29.52	53.16	100.0

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Interpolated data for 1300-1600 hours on 6 June, and 1500-1600 hours on 8 June.

Table 2. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Kvichak River, 1987.

	Age I			Age II			Age III			All Ages	
Date[a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 21	240,478	.87	240,478	27,400,773	99.13	27,400,773	0	.00	0	27,641,251	27,641,251
5 22	35,352	.87	275,830	4,028,207	99.13	31,428,980	0	.00	0	4,063,559	31,704,810
5 23	27,241	1.66	303,071	1,613,784	98.34	33,042,764	0	.00	0	1,641,025	33,345,835
5 24	36,911	.14	339,982	26,328,411	99.86	59,371,175	0	.00	0	26,365,322	59,711,157
5 25	120,104	.57	460,086	20,950,901	99.43	80,322,076	0	.00	0	21,071,005	80,782,162
5 26	130,606	1.32	590,692	9,763,826	98.68	90,085,902	0	.00	0	9,894,432	90,676,594
5 27	281,589	.75	872,281	37,222,344	99.14	127,308,246	41,299	.11	41,299	37,545,232	128,221,826
5 28	324,169	.71	1,196,450	45,283,282	99.18	172,591,528	50,223	.11	91,522	45,657,674	173,879,500
5 29	466,155	1.58	1,662,605	29,004,894	98.31	201,596,422	32,453	.11	123,975	29,503,502	203,383,002
5 30	828,305	3.63	2,490,910	21,990,028	96.37	223,586,450	0	.00	123,975	22,818,333	226,201,335
5 31	63,453	1.57	2,554,363	3,978,191	98.43	227,564,641	0	.00	123,975	4,041,644	230,242,979
6 1	154,384	2.40	2,708,747	6,278,314	97.60	233,842,955	0	.00	123,975	6,432,698	236,675,677
6 2	1,024,765	6.50	3,733,512	14,740,857	93.50	248,583,812	0	.00	123,975	15,765,622	252,441,299
6 3	319,045	6.49	4,052,557	4,596,903	93.51	253,180,715	0	.00	123,975	4,915,948	257,357,247
6 4	223,943	10.63	4,276,500	1,882,767	89.37	255,063,482	0	.00	123,975	2,106,710	259,463,957
6 5	637,709	11.00	4,914,209	5,159,647	89.00	260,223,129	0	.00	123,975	5,797,356	265,261,313
6 6	964,857	12.03	5,879,066	7,055,568	87.97	267,278,697	0	.00	123,975	8,020,425	273,281,738
6 7	729,440	5.05	6,608,506	13,714,924	94.95	280,993,621	0	.00	123,975	14,444,364	287,726,102
6 8	665,606	3.96	7,274,112	16,142,628	96.04	297,136,249	0	.00	123,975	16,808,234	304,534,336
6 9	348,273	3.37	7,622,385	9,986,245	96.63	307,122,494	0	.00	123,975	10,334,518	314,868,854
6 10	2,160,559	15.08	9,782,944	12,166,760	84.92	319,289,254	0	.00	123,975	14,327,319	329,196,173
6 11	418,636	11.67	10,201,580	3,168,648	88.33	322,457,902	0	.00	123,975	3,587,284	332,783,457
6 12	701,318	11.96	10,902,898	5,162,549	88.04	327,620,451	0	.00	123,975	5,863,867	338,647,324
6 13	275,500	6.82	11,178,398	3,764,094	93.18	331,384,545	0	.00	123,975	4,039,594	342,686,918
	11,178,398	3.26		331,384,545	96.70		123,975	.04		342,686,918	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt in the Kvichak River, 1987.

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
5 21	7.0	11.8
5 22	7.0	11.8
5 23	6.8	12.3
5 24	7.4	11.3
5 25	7.1	11.7
5 26	7.0	11.8
5 27	7.3	11.4
5 28	7.2	11.6
5 29	6.9	12.0
5 30	6.8	12.3
5 31	6.9	12.0
6 1	7.2	11.6
6 2	6.6	12.6
6 3	6.0	13.8
6 4	5.9	14.0
6 5	6.1	13.6
6 6	6.6	12.7
6 7	7.1	11.7
6 8	7.2	11.6
6 9	6.7	12.4
6 10	6.2	13.5
6 11	6.2	13.4
6 12	6.5	12.8
6 13	6.6	12.6

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 4. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-85 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
		Estimates of smolt numbers based upon fyke net catches				
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.640
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.225
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.134
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.144
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.359
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.463
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.855
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.259
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.496
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.343
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.315
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.278
1968	2,557,440	185,356				
		Estimates of smolt numbers based upon sonar techniques				
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.664
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.009
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.120
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.211
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.197
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.843
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.205
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.753
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.564
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	199,172,858	12.948
1981	1,754,358	6,549,125 (15)	37,595,987 (85)	0	44,145,112	25.163
1982	1,134,840	51,893,988 (96)	1,937,408 (4)	2,065	53,833,461	47.437
1983	3,569,982	23,590,443 (31)	53,260,693 (69)	123,975	76,975,111	21.562
1984	10,490,670	83,470,460 (20)	331,384,545 (80)		414,855,005[a]	39.545
1985	7,211,046	11,178,398				

[a] Preliminary total

Table 5. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival for 1952-85 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult[a] Returns	Adult[b] Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult[b] Returns per Smolt
		Estimates of smolt numbers based upon fyke net catches					
1952	-	-			241,870	3,610,258	14.93
1953	-	18,198	152,165	8.36	47,373	424,627	8.96
1954	-	30,287	109,965	3.63	8,654	659,246	76.18
1955	-	22,253	351,240	15.78	66,679	1,132,813	16.99
1956	9,443,318	3,267,274	31,253,977	9.57	2,777,960	7,773,131	2.80
1957	2,842,810	85,916	488,844	5.69	552,603	3,591,552	6.50
1958	534,785	61,400	124,250	2.02	10,126	161,253	15.92
1959	680,000	26,038	328,287	12.61	72,180	217,593	3.01
1960	14,630,000	1,130,820	1,877,221	1.66	4,116,093	53,360,190	12.96
1961	3,705,849	113,338	524,416	4.63	1,603,464	2,971,816	1.85
1962	2,580,884	458,122	256,253	0.56	1,748,178	5,083,162	2.91
1963	338,760	64,377	98,571	1.53	23,377	1,008,242	43.13
1964	957,120	252,384	2,647,042	10.49	222,528	3,093,042	13.90
1965	24,325,926	2,866,214	10,349,415	3.61	5,475,362	34,671,692	6.33
1966	3,775,184	648,321	1,594,186	2.46	541,017	4,657,432	8.61
1967	3,216,208	594,327	621,690	1.05	298,282	900,307	3.02
1968	2,557,440	185,356	332,177	1.79	-		
		Estimates of smolt numbers based upon sonar techniques					
1968	2,557,440	-			5,959,383	209,105	0.04
1969	8,394,204	85,723,430	449,876	0.01	54,159,340	4,823,046	0.09
1970	13,935,306	464,219	56,805	0.12	191,842,930	15,350,282	0.08
1971	2,387,392	5,123,400	337,402	0.07	21,423,246	2,490,225	0.12
1972	1,009,962	2,740,610	436,664	0.16	-	1,504,342	-
1973	226,554	-	1,607,253	-	3,031,287	818,392	0.27
1974	4,433,844	108,356,892	8,353,688	0.08	114,269,848	17,797,272	0.16
1975	13,140,450	78,308,251	6,919,726	0.09	213,364,470	31,164,419	0.15
1976	1,965,282	32,226,544	6,132,602	0.19	26,423,348	4,431,287	0.17
1977	1,341,144	28,758,191	2,910,136	0.10	10,410,467	307,905	0.03
1978	4,149,288	182,442,540	2,989,871	0.02	32,294,536	2,169,833	0.07
1979	11,218,434	219,928,232	20,631,921	0.09	89,300,703	21,194,617	0.24
1980	22,505,268	150,421,026	4,536,972	0.03	76,244,773	8,527,417	0.11
1981	1,754,358	6,549,125	1,034,266	0.16	37,595,987	1,097,260	0.03
1982	1,134,840	51,893,988	991,093	0.02	1,937,408	662,874	0.34
1983	3,569,982	23,590,443	11,609,804	0.49	53,260,693	1,207,394	0.02[c]
1984	10,490,670	83,470,460	2,546,801	0.03[c]	331,384,545	44,069	0.00[c]
1985	7,211,046	11,178,398	6,561	0.00[c]			

[a] Includes estimates of returns through 1988.

[b] Greater than 1 adult return per smolt, based on fyke net catches, means smolt outmigration was underestimated.

[c] Future adult returns will increase these values.

Table 6. Mean fork length and weight of sockeye salmon smolt captured in fyke nets in the Kvichak River, 1987.

	Age I					Age II					Age III				
Date[a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 22	88	.0	5.1	.00	1	98	22.6	7.4	4.71	100	--	--	--	--	0
5 23	85	4.8	5.1	.24	2	94	18.3	6.9	3.78	78	--	--	--	--	0
5 24	--	--	--	--	0	99	21.9	8.3	5.46	100	--	--	--	--	0
5 25	--	--	--	--	0	96	19.2	7.2	3.71	100	--	--	--	--	0
5 26	--	--	--	--	0	97	20.9	7.1	4.15	100	--	--	--	--	0
5 27	83	.0	4.5	.00	1	98	20.2	7.4	4.11	98	113	.0	12.8	.00	1
5 28	--	--	--	--	0	96	21.9	7.0	4.61	99	92	.0	7.4	.00	1
5 29	--	--	--	--	0	96	18.6	7.2	4.18	98	88	.0	5.3	.00	1
5 30	79	8.1	3.9	.98	3	96	20.6	7.4	4.08	97	--	--	--	--	0
5 31	82	3.7	4.9	1.06	3	96	25.3	7.3	5.03	97	--	--	--	--	0
6 1	90	.6	6.2	.61	3	99	23.7	7.8	5.00	122	--	--	--	--	0
6 2	81	.0	4.0	.00	1	95	22.3	6.9	4.07	74	--	--	--	--	0
6 3	80	4.4	4.2	.81	4	91	15.4	6.0	3.06	71	--	--	--	--	0
6 4	84	4.7	4.7	1.01	4	91	20.6	6.1	3.64	85	--	--	--	--	0
6 5	82	8.4	4.5	1.36	12	91	21.7	6.2	4.38	91	--	--	--	--	0
6 6	82	9.2	4.6	2.02	17	96	30.1	7.1	6.55	82	--	--	--	--	0
6 7	79	13.5	4.1	2.20	8	98	24.3	7.3	4.53	92	--	--	--	--	0
6 8	81	11.9	4.1	1.83	3	97	21.2	7.0	4.04	97	--	--	--	--	0
6 9	80	2.1	4.3	.38	3	96	18.3	6.6	2.87	56	--	--	--	--	0
6 10	79	13.3	4.2	2.07	20	95	20.8	6.5	3.28	80	--	--	--	--	0
6 11	78	14.4	4.5	2.31	11	94	19.2	6.5	3.30	89	--	--	--	--	0
6 12	79	8.9	4.1	1.34	16	95	20.1	6.6	3.75	84	--	--	--	--	0
6 13	82	8.6	4.9	1.63	7	95	23.3	7.0	4.85	68	--	--	--	--	0
Totals					119					2,058					3
Means	82		4.5			96		7.0			97		8.5		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 7. Age composition of total migration, and mean fork length and weight by age class, for sockeye salmon smolt in the Kvichak River, 1955-87.

Year of Migration	Age I			Age II			Age III			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1955[a]	7	89	-	93	-	-	0	-	-	260,068	Paulus and Parker (1974)
1956	39	92	-	61	116	-	0	-	-	77,660	"
1957	72	96	7.3	28	120	14.4	0	-	-	30,907	"
1958	98	84	4.6	2	114	-	0	-	-	3,333,953	"
1959	3	80	-	97	99	7.6	0	-	-	2,863,876	"
1960	10	91	6.3	90	108	10.3	0	-	-	614,003	"
1961	72	92	6.8	28	117	13.1	0	-	-	36,164	"
1962	94	82	4.3	6	110	9.9	0	-	-	1,203,000	"
1963	3	83	4.8	97	98	7.5	0	-	-	4,229,431	Marriott (1965)
1964	22	87	5.2	78	108	9.8	0	-	-	2,061,586	Pennoyer and Seibel (1965)
1965	4	90	6.8	96	109	11.3	0	-	-	1,812,555	Pennoyer (1966)
1966	92	94	7.4	8	114	12.6	0	-	-	275,761	Pennoyer and Stewart (1967)
1967	93	86	5.9	7	118	14.2	0	-	-	3,088,742	Pennoyer and Stewart (1969)
1968	11	88	5.5	89	104	9.2	0	-	-	6,123,683	Paulus and McCurdy (1969)
1969	52	92	5.7	48	109	10.6	0	-	-	1,135,344	McCurdy and Paulus (1972)
1970	38	91	6.0	62	110	11.0	0	-	-	483,638	Paulus and McCurdy (1972)
1971	93	90	5.8	7	111	11.1	0	-	-	91,682,813	Russell (1972)
1972	1	80	4.2	99	106	10.0	0	-	-	54,623,559	Parker (1974a)
1973	3	86	5.1	97	97	8.3	0	-	-	196,966,331	Parker (1974b)
1974	9	96	8.3	79	111	13.1	12	124	17.5	27,082,626	Krasnowski (1975)
1975	63	98	8.4	37	122	16.4	0	-	-	15,632,531	Randall (1976)
1976	97	88	5.8	3	121	14.2	0	-	-	111,388,180	Randall (1977)
1977	38	86	5.5	62	106	10.1	0	-	-	192,578,099	Randall (1978)
1978	12	88	6.0	88	97	7.8	0	-	-	245,591,014	Yuen (1980a)
1979	51	90	6.0	49	109	10.3	0	-	-	55,181,540	Yuen (1980b)
1980	94	88	5.9	6	110	10.7	0	-	-	192,853,007	Yuen and Wise (1982)
1981	89	85	5.4	11	108	10.2	0	-	-	252,222,769	Bergstrom and Yuen (1981)
1982	58	84	5.1	39	103	9.1	0	-	-	239,721,729	Bill (1984)
1983	8	80	4.9	92	98	8.5	0	-	-	82,793,899	Bill et al. (1987)
1984	58	90	6.8	42	104	10.0	0	-	-	89,489,975	Bill (1986)
1985	92	85	5.3	8	102	9.2	0	-	-	25,527,851	Bill (1986)
1986	61	84	5.5	39	107	10.4	0	102	9.1	136,733,218	Bue et al. (1988)
	Mean	88	5.9		109	10.7		113	13.3		
1987	3	82	4.5	97	96	7.0	0	97	8.5		

[a] Estimates of smolt numbers 1955-70 based on fyke net catches, estimates of smolt numbers 1971-1987 based on sonar techniques.

Table 8. Mean fork length and estimated weight, by estimated age of sockeye salmon smolt length frequencies in the Kvichak River, 1987.

	Estimated Age I				Estimated Age II			
Date[a]	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5 22[b]	81	1.2	4.4	4	96	32.6	7.0	610
5 23	81	2.4	4.4	7	94	27.3	6.7	355
5 24	78	.0	3.9	1	97	31.5	7.2	656
5 25	79	4.8	4.1	5	96	30.5	7.0	586
5 26	79	4.2	4.1	10	96	31.7	7.0	577
5 27	78	7.1	4.0	5	97	31.8	7.2	602
5 28	73	6.1	3.4	5	97	33.4	7.2	613
5 29	73	10.2	3.4	11	95	33.1	6.9	590
5 30	75	9.5	3.6	24	94	32.4	6.8	588
5 31	78	9.6	4.1	10	95	35.7	6.8	574
6 1	76	11.0	3.8	17	97	39.5	7.2	601
6 2	75	14.7	3.6	46	94	35.3	6.7	518
6 3	79	5.4	4.1	32	90	24.8	6.0	420
6 4	77	13.4	3.9	64	90	27.1	6.0	435
6 5	78	9.6	4.0	64	91	29.0	6.2	525
6 6	78	12.1	3.9	90	93	36.7	6.4	526
6 7	77	11.0	3.8	35	97	35.6	7.3	571
6 8	76	11.5	3.7	30	98	33.7	7.4	583
6 9	77	7.8	3.9	14	94	25.8	6.7	332
6 10	76	12.1	3.7	104	93	29.5	6.5	516
6 11	77	11.8	3.8	77	93	28.5	6.4	526
6 12	76	11.3	3.6	69	95	32.0	6.8	528
6 13	76	10.7	3.8	37	94	30.5	6.6	453
Totals				761				12,285
Means	77		3.9		95		6.8	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Length-weight parameters by age group and discriminating length used to separate ages for 22 May through 13 June were:
age I a= -10.93 b= 2.82 r^2= .68 n= 61
age II a= - 9.70 b= 2.55 r^2= .81 n= 820
discriminating length = 87.1

Table 9. Climatological and hydrological observations made at sockeye salmon smolt counting site for the Kvichak River, 1987.

Date	Cloud Cover[a]		Wind Velocity (km/hr)		Air Temp. (°C)		Mean Water Temp. (°C)	Precipitation (mm)	Water Color
	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours			
5 20	-	-	-	10-15	-	-	4.5	-	-
5 21	3	4	5 E	10-15 E	-	5.5	4.5	0.76	clear
5 22	4	4	calm	0-5 NE	6.0	8.5	5.2	5.08	clear
5 23	4	3	0-5 SW	20 SW	6.5	9.5	5.1	7.87	clear
5 24	3	1	5-10 SW	0-5 NE	5.5	9.8	5.4	0.00	clear
5 25	4	3	15-20 NE	0-5 NE	9.0	12.0	5.4	4.32	murky
5 26	3	3	0-5 NE	calm	8.0	9.0	5.2	52.07	lt. brn.
5 27	3	3	5-15 W	5 W	3.5	13.0	5.8	1.27	brown
5 28	3	2	5 W	5 N	6.5	11.5	5.9	4.06	clear
5 29	3	4	5 NE	0-5 N	7.0	11.7	6.3	1.02	clear
5 30	2	3	0-5 W	0-5 NW	7.0	12.0	7.1	0.25	clear
5 31	2	3	5 NW	5 W	7.0	15.1	7.7	0.00	clear
6 1	3	4	5-10 W	10-12 S	7.5	12.0	7.3	2.03	lt. brn.
6 2	4	3	0-5 W	0-5 SW	7.0	11.5	7.0	2.79	lt. brn.
6 3	2	2	0-5 W	0-5 N	7.0	21.5	7.3	0.00	lt. brn.
6 4	2	4	calm	0-5 NE	7.5	20.0	7.5	trace	-
6 5	3	3	0-5 SW	0-5 NE	8.1	22.5	7.2	trace	clear
6 6	4	3	0-5 E	5-10 E	-	11.5	7.4	0.25	clear
6 7	2	2	5-10 NE	15 E	8.2	12.0	7.5	0.00	clear
6 8	1	3	5-10 NE	15-20 E	9.9	24.0	7.8	0.00	lt.brn.
6 9	3	3	15-25 NE	15-20 NE	12.5	14.5	7.5	0.00	brown
6 10	3	3	10-15 NE	0-5 N	10.0	11.5	7.7	trace	clear
6 11	2	4	0-5 NE	5 N	10.0	19.5	8.3	0.00	clear
6 12	2	3	10-15 SW	10-15 SE	10.5	11.0	8.0	0.51	clear
6 13	1	4	10-12 SW	15-17 S	8.0	11.0	7.2	0.00	clear
6 14	4	-	10 S	-	8.0	-	7.5	-	lt. brn.

[a] 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 10. Water temperatures at sockeye salmon smolt counting site for the Kvichak River, 1963-87.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	References
1963	16 May-14 June	2.2	8.9	5.5	Marriott (1965)
1964	18 May-14 June	0.0	5.6	2.6	Pennoyer and Seibel (1965)
1965	17 May-11 June	0.0	8.9	4.4	Pennoyer (1966)
1966	16 May-26 June	0.0	11.1	4.7	Pennoyer and Stewart (1967)
1967	17 May-20 June	1.1	9.4	6.9	Pennoyer and Stewart (1969)
1968	12 May-12 June	3.3	8.3	5.4	Paulus and McCurdy (1969)
1969	16 May-18 June	0.3	7.8	3.9	McCurdy and Paulus (1972)
1970	13 May- 7 June	2.8	11.1	6.8	Paulus and McCurdy (1972)
1971	17 May-20 June	1.1	3.3	2.4	Russell (1972)
1972	18 May-18 June	0.6	5.0	2.9	Parker (1974a)
1973	15 May-14 June	2.9	8.9	4.9	Parker (1974b)
1974	13 May- 9 June	3.0	8.0	6.2	Krasnowski (1975)
1975	17 May-15 June	2.0	8.0	3.8	Randall (1976)
1976	18 May-19 June	2.0	9.5	3.9	Randall (1977)
1977	17 May-14 June	3.0	9.5	6.4	Randall (1978)
1978	19 May- 9 June	5.0	11.0	7.6	Yuen (1980a)
1979	1 June-10 June	8.0	10.0	8.6	Yuen (1980b)
1980	16 May-18 June	1.5	9.0	5.5	Bergstrom and Yuen (1981)
1981	15 May- 9 June	7.0	10.0	8.2	Yuen and Wise (1982)
1982	14 May-15 June	2.5	8.5	4.9	Bill (1984)
1983	19 May-14 June	5.2	10.5	7.9	Bill et al. (1987)
1984	19 May-11 June	5.5	10.0	7.9	Bill (1986)
1985	23 May-20 June	2.0	7.0	4.6	Bill (1986)
1986	18 May-12 June	1.0	7.0	4.6	Bue et al. (1988)
	Mean	2.6	8.6	5.4	
1987	21 May-13 June	4.5	9.0	6.7	

Table 11. Sonar counts recorded from three arrays each, with 10 transducers at the sockeye salmon smolt counting site on the Egegik River, 1987.

Date[a]	Sonar Counts: Transducer Array: Inshore	Center	Offshore	Total
5 19	15,022	25,279	18,195	58,496
5 20	153,411	170,990	88,774	413,175
5 21	49,676	54,167	7,861	111,704
5 22	149,042	673,301	101,663	924,006
5 23	51,761	329,064	249,450	630,275
5 24	229,040	254,566	26,843	510,449
5 25	47,502	276,829	144,043	468,374
5 26[b]	47,625	36,314	43,429	127,368
5 27	13,621	128,053	91,429	233,103
5 28	3,961	19,493	11,121	34,575
5 29	6,441	8,446	4,522	19,409
5 30	1,326	16,812	17,483	35,621
5 31	785	19,082	70,135	90,002
6 1	1,687	16,670	50,675	69,032
6 2	3,902	19,446	7,590	30,938
6 3	8,247	21,818	2,663	32,728
6 4	5,961	36,022	48,467	90,450
6 5	12,981	33,355	54,274	100,610
6 6	43,137	35,942	20,923	100,002
6 7	21,543	38,711	47,620	107,874
6 8	17,556	128,018	58,698	204,272
6 9	42,121	75,832	69,251	187,204
6 10	4,034	7,132	7,438	18,604
6 11	6,891	18,534	16,753	42,178
6 12	797	807	811	2,415
6 13	4,515	5,667	9,302	19,484
Total	942,585	2,450,350	1,269,413	4,662,348
Percent	20.22	52.56	27.23	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Interpolated data for 0300-0500 hours on 26 May.

Table 12. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Egegik River, 1987.

	Age I			Age II			Age III			All Ages	
Date[a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 19	21,512	3.60	21,512	575,037	96.23	575,037	1,015	.17	1,015	597,564	597,564
5 20	154,015	3.60	175,527	4,116,921	96.23	4,691,958	7,272	.17	8,287	4,278,208	4,875,772
5 21	42,188	3.60	217,715	1,127,711	96.23	5,819,669	1,992	.17	10,279	1,171,891	6,047,663
5 22	327,180	3.60	544,895	8,745,720	96.23	14,565,389	15,450	.17	25,729	9,088,350	15,136,013
5 23	223,941	3.60	768,836	5,986,081	96.23	20,551,470	10,575	.17	36,304	6,220,597	21,356,610
5 24	433,338	7.81	1,202,174	5,115,175	92.19	25,666,645	0	.00	36,304	5,548,513	26,905,123
5 25	882,426	16.67	2,084,600	4,388,310	82.90	30,054,955	22,762	.43	59,066	5,293,498	32,198,621
5 26	116,390	7.62	2,200,990	1,411,046	92.38	31,466,001	0	.00	59,066	1,527,436	33,726,057
5 27	339,590	13.39	2,540,580	2,178,296	85.89	33,644,297	18,006	.71	77,072	2,535,892	36,261,949
5 28	11,385	3.35	2,551,965	328,494	96.65	33,972,791	0	.00	77,072	339,879	36,601,828
5 29	8,446	4.12	2,560,411	195,727	95.47	34,168,518	820	.40	77,892	204,993	36,806,821
5 30	12,182	3.51	2,572,593	333,987	96.23	34,502,505	902	.26	78,794	347,071	37,153,892
5 31	95,708	9.68	2,668,301	891,533	90.17	35,394,038	1,384	.14	80,178	988,625	38,142,517
6 1	62,691	8.64	2,730,992	661,885	91.22	36,055,923	1,015	.14	81,193	725,591	38,868,108
6 2	46,830	14.47	2,777,822	276,357	85.39	36,332,280	453	.14	81,646	323,640	39,191,748
6 3	29,097	8.79	2,806,919	301,440	91.06	36,633,720	496	.15	82,142	331,033	39,522,781
6 4	80,959	8.72	2,887,878	846,085	91.13	37,479,805	1,299	.14	83,441	928,343	40,451,124
6 5	146,953	13.39	3,034,831	948,889	86.46	38,428,694	1,646	.15	85,087	1,097,488	41,548,612
6 6	173,221	14.26	3,208,052	1,041,514	85.74	39,470,208	0	.00	85,087	1,214,735	42,763,347
6 7	174,302	13.57	3,382,354	1,110,167	86.43	40,580,375	0	.00	85,087	1,284,469	44,047,816
6 8	227,948	9.93	3,610,302	2,067,607	90.07	42,647,982	0	.00	85,087	2,295,555	46,343,371
6 9	547,295	22.13	4,157,597	1,925,798	77.87	44,573,780	0	.00	85,087	2,473,093	48,816,464
6 10	54,655	22.76	4,212,252	185,483	77.24	44,759,263	0	.00	85,087	240,138	49,056,602
6 11	120,831	22.76	4,333,083	410,063	77.24	45,169,326	0	.00	85,087	530,894	49,587,496
6 12	7,096	22.76	4,340,179	24,083	77.24	45,193,409	0	.00	85,087	31,179	49,618,675
6 13	56,908	22.76	4,397,087	193,127	77.24	45,386,536	0	.00	85,087	250,035	49,868,710
Total	4,397,087	8.82		45,386,536	91.01		85,087	.17		49,868,710	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 13. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt in the Egegik River, 1987.

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
5 18	15.5	2.7
5 19	15.5	2.7
5 20	15.5	2.7
5 21	15.5	2.7
5 22	15.5	2.7
5 23	15.5	2.7
5 24	14.9	2.8
5 25	14.2	2.9
5 26	14.9	2.8
5 27	14.5	2.9
5 28	16.3	2.5
5 29	16.4	2.5
5 30	16.3	2.5
5 31	15.0	2.8
6 1	14.8	2.8
6 2	14.5	2.9
6 3	15.1	2.8
6 4	15.2	2.7
6 5	14.4	2.9
6 6	13.1	3.2
6 7	13.2	3.1
6 8	13.8	3.0
6 9	12.3	3.4
6 10	12.5	3.3
6 11	12.5	3.3
6 12	12.5	3.3
6 13	12.5	3.3

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 14. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1978-85 brood years, Egegik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1978	895,698	-	-	225,522	-	-
1979	1,032,042	-	14,287,075	0	-	-
1980	1,060,860	49,457,563 (75)	16,524,563 (25)	197,429	66,179,555	62.38
1981	694,680	2,242,326 (7)	32,235,734 (93)	52,852	34,530,912	49.71
1982	1,034,628	17,234,269 (60)	11,434,848 (40)	564	28,669,681	27.71
1983	792,282	54,585,828 (65)	29,984,140 (35)	85,087	84,655,055	106.84
1984	1,165,320	14,016,441 (24)	45,386,536 (76)		59,402,977	50.98[a]
1985	1,095,204	4,397,087				

[a] Preliminary, age-III outmigration in 1988 may increase this total.

Table 15. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival for 1978-85 brood years, Egegik River.

Brood Year	Total Spawning Escapement	Age I			Age II			Age III		
		Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult[b] Returns per Smolt
1978	895,698	-	907,413		-	8,310,922		225,522	33,756	0.15
1979	1,032,042	-	1,246,161		14,287,075	4,737,895	0.33	0	0	0.00
1980	1,060,860	49,457,563	3,027,613	0.06	16,524,563	5,502,662	0.33	197,429	7,888	0.04
1981	694,680	2,242,326	1,532,938	0.68	32,235,734	4,875,574	0.15	52,852	16,104	0.30
1982	1,034,628	17,234,269	2,901,170	0.17	11,434,848	3,440,847	0.30	564	11,061	19.61[c]
1983	792,282	54,585,828	4,500,985	0.08	29,984,140	3,221,380	0.11[c]	85,087	0	0.00[c]
1984	1,165,320	14,016,441	604,273	0.04[c]	45,386,536	85,527	0.00[c]			
1985	1,095,204	4,397,087	341	0.00[c]						

[a] Includes estimates of returns through 1988.

[b] Greater than 1 adult return per smolt means smolt outmigration was underestimated.

[c] Future adult returns will increase these values.

Table 16. Mean fork length and weight of sockeye salmon smolt captured in fyke nets in the Egegik River, 1987.

	Age I					Age II					Age III				
Date[a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 23	112	6.2	12.1	1.88	5	118	19.4	15.0	7.78	93	132	.0	20.6	.00	1
5 24	107	9.5	11.3	2.94	16	116	18.7	14.3	6.69	84	--	--	--	--	0
5 25	110	11.1	12.6	4.57	4	120	15.5	15.6	6.96	92	127	6.6	19.3	2.70	3
5 26	105	4.6	11.1	1.59	8	114	19.5	14.0	7.56	91	--	--	--	--	0
5 27	105	5.6	11.1	2.66	5	118	19.7	15.5	7.80	90	132	1.3	20.7	1.24	5
5 28	103	7.4	11.1	2.48	9	116	19.2	15.4	7.36	78	--	--	--	--	0
5 29	118	7.7	16.2	3.57	2	120	21.3	16.9	8.34	95	123	2.4	17.0	1.01	2
5 30	108	3.8	12.4	0.81	3	117	22.8	15.5	8.91	94	127	2.4	18.4	.30	2
5 31	105	7.1	11.5	2.24	10	115	19.7	14.6	7.17	89	125	.0	19.3	.00	1
6 1	107	6.9	11.6	2.28	16	117	19.2	14.6	7.56	83	132	.0	19.1	.00	1
6 2	108	7.6	12.0	2.36	10	117	25.7	15.5	8.79	89	138	.0	21.4	.00	1
6 3	110	11.4	12.6	3.59	11	118	20.9	15.0	7.45	86	110	.0	12.2	.00	1
6 4	108	8.9	11.8	3.00	16	119	21.4	14.8	7.65	83	133	.0	19.6	.00	1
6 5	107	10.8	11.1	3.75	26	114	19.7	13.3	6.83	71	134	.0	20.5	.00	1
6 6	102	7.9	10.0	2.92	34	109	18.3	11.7	6.14	66	--	--	--	--	0
6 7	103	11.1	10.6	3.56	34	112	22.4	13.1	7.25	66	--	--	--	--	0
6 8	103	9.8	10.8	3.09	31	108	17.0	12.2	5.32	67	--	--	--	--	0
6 9	105	13.7	10.7	4.11	30	109	18.1	11.5	6.03	70	--	--	--	--	0
6 10	103	9.0	10.6	3.64	34	105	13.7	11.4	4.77	45	--	--	--	--	0
6 11	105	12.2	11.0	5.27	40	108	14.8	11.9	4.86	58	--	--	--	--	0
Totals					344					1,590					19
Means	107		11.6			114		14.1			128		18.9		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 17. Mean fork length and weight of sockeye salmon smolt sampled from the Egegik River, 1939-87.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1939	-	-	96	-	105	-	-	-	USF&WS (unpublished)
1956	-	386	101	-	116	-	123	-	"
1957	-	236	107	-	120	-	130	-	"
1959	-	281	99	-	116	-	123	-	"
1960	-	159	106	-	115	-	140	-	"
1969	-	67	99	-	119	-	115	-	Paulus (1972)
1977	27-29 May	299	110	11.3	116	13.3	-	-	ADF&G (unpublished)
1978	19-22 May	319	104	10.1	122	15.4	130	18.1	Huttunen (1980)
1981	15 May- 6 June	549	105	9.1	122	16.6	128	19.1	Bue (1982)
1982	27 May-15 June	881	104	9.2	130	17.1	145	23.5	Bue (1984)
1983[a]	17 May- 9 June	2,631	101	9.3	116	13.6	-	-	Fried and Yuen (in press)
1984[a]	10 May-10 June	3,602	106	10.1	112	12.2	134	20.2	Fried et al. (1986)
1985[a]	24 May- 5 June	5,427	106	10.4	123	16.8	138	24.1	Bue (1986)
1986	18 May-11 June	1,120	101	9.0	122	15.7	140	22.6	Bue et al. (1988)
		Mean	103	9.8	118	15.1	131	21.3	
1987	23 May-11 June	1,953	107	11.6	114	14.1	128	18.9	

[a] Age, weight, and length samples pooled with estimated weight by age from length samples.

Table 18. Mean fork length and estimated weight, by estimated age of sockeye salmon smolt length frequencies in the Egegik River, 1987.

Date[a]	Estimated Age I Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Estimated Age II Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5 23[b]	104	4.4	10.7	21	119	30.3	15.7	472
5 24	104	6.1	10.6	43	118	31.1	15.3	488
5 25	103	8.5	10.5	130	116	27.8	14.5	451
5 26	104	4.8	10.7	44	118	29.6	15.3	482
5 27	104	6.8	10.7	92	117	29.7	14.8	431
5 28	104	4.1	10.6	13	122	32.6	16.9	497
5 29	105	4.1	10.8	17	122	28.4	16.8	295
5 30	104	6.3	10.6	24	122	34.3	16.9	515
5 31	104	6.4	10.7	58	118	31.6	15.5	453
6 1	105	4.3	10.9	45	118	31.6	15.2	459
6 2	103	8.1	10.5	75	117	30.7	14.9	366
6 3	104	6.1	10.7	53	118	33.6	15.5	466
6 4	104	6.1	10.8	47	119	33.3	15.6	490
6 5	104	6.4	10.7	67	117	29.1	14.9	426
6 6	101	6.4	10.0	73	114	29.4	13.3	462
6 7[c]	101	6.4	10.0	66	114	29.6	13.3	486
6 8	101	5.2	10.0	36	116	33.5	14.2	438
6 9	101	7.7	9.9	125	110	22.7	12.4	375
6 10	101	4.7	10.1	44	111	18.1	12.7	121
6 11	102	4.6	10.1	38	112	21.0	12.8	208
Totals				1,111				8,381
Means	103		10.5		117		14.8	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Length-weight parameters by age group and discriminating length used to separate ages for 23 May through 6 June were:
age I a= - 9.85 b= 2.63 r^2= .73 n= 138
age II a= -10.52 b= 2.77 r^2= .82 n= 1172
discriminating length = 107.40

[c] Length-weight parameters by age group and discriminating length used to separate ages for 7 June through 12 June were:
age I a= -10.62 b= 2.80 r^2= .71 n= 202
age II a= - 9.36 b= 2.52 r^2= .77 n= 370
discriminating length = 104.47

Table 19. Climatological and hydrological observations made at sockeye salmon smolt counting site for the Egegik River, 1987.

Date	Cloud Cover[a]		Wind Velocity (km/hr)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Color
	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours		
5 18	1	4	10-15 NE	-	-	-	7.5	-	-	-
5 19	4	4	NE	NNE	2.0	14.0	6.0	4.9	-	clear
5 20	1	4	NE	15 SSE	3.0	8.0	4.0	4.9	6.60	clear
5 21	3	4	NE	20 E	2.0	7.0	4.0	3.9	1.78	clear
5 22	4	4	NE	5 E	6.0	8.0	4.0	4.0	1.02	clear
5 23	4	3	SW	2 S	4.0	9.0	4.9	5.0	7.37	clear
5 24	4	4	NE	15 E	1.0	9.0	4.0	6.0	0.00	clear
5 25	4	4	NE	10 E	4.0	9.0	4.0	5.1	0.51	clear
5 26	4	4	NE	10 SW	2.0	8.0	4.5	6.5	5.59	clear
5 27	3	3	NE	5 SW	1.0	7.0	5.0	7.0	2.29	clear
5 28	3	3	SW	calm	1.0	12.0	5.0	7.9	0.00	clear
5 29	3	4	SW	1-2 W	3.0	11.0	6.0	6.5	7.37	clear
5 30	-	4	-	5 SW	5.0	13.0	-	7.0	1.02	clear
5 31	4	3	NE	5-8 SSW	6.0	12.0	7.0	8.5	0.00	clear
6 1	4	4	NE	1-5 W	4.0	9.0	5.5	5.1	0.00	clear
6 2	4	4	NE	SE	3.0	11.0	8.0	5.5	1.27	clear
6 3	3	1	SE	1 SE	4.0	15.0	5.2	8.0	0.00	clear
6 4	1	3	E	2 E	5.0	16.0	-	8.0	0.00	clear
6 5	4	4	NE	2 S	6.0	12.0	7.5	7.9	1.02	clear
6 6	1	4	NE	2 E	6.0	12.0	6.0	9.0	1.78	clear
6 7	3	2	SE	10 SE	2.0	14.0	5.0	9.0	0.00	clear
6 8	1	4	E	20 E	4.0	12.0	6.5	8.0	0.00	clear
6 9	4	3	E	10 E	7.0	13.0	6.0	9.0	0.25	clear
6 10	1	3	N	5 NNE	4.0	16.0	7.0	10.0	0.00	clear
6 11	3	3	N	1-2 W	4.0	16.0	7.0	9.5	0.25	clear
6 12	4	3	SW	5-10 SSW	7.0	12.0	9.0	8.5	1.27	clear
6 13	2	3	SW	1-2 W	5.0	11.7	11.0	8.0	0.00	clear
6 14	4	-	SW	-	-	-	11.0	-	-	clear

[a] 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 20. Water temperatures at sockeye salmon smolt counting site for the Egegik River, 1981-87.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	Reference
1981	15 May-8 June	5.0	9.0	7.3	Bue (1982)
1982	15 May-16 June	0.0	5.0	2.9	Bue (1984)
1983	18 May-10 June	5.0	9.5	7.0	Fried et al. (1987)
1984	17 May-11 June	5.0	10.0	7.6	Fried et al. (1986)
1985	17 May-12 June	2.5	7.5	4.2	Bue (1986)
1986	19 May-12 June	2.2	7.5	7.2	Bue et al. (1988)
	Mean	3.3	8.1	6.0	
1987	18 May-13 June	3.9	11.0	6.6	

Table 21. Sonar counts recorded from two arrays, each with 10 transducers at the sockeye salmon smolt counting site on the Ugashik River, 1987.

Date[a]	Sonar Counts: Transducer Array: Inshore	Sonar Counts: Transducer Array: Offshore	Sonar Counts: Total
5 17	4,274	7,237	11,511
5 18	27,327	33,649	60,976
5 19	6,490	11,306	17,796
5 20	59,271	46,484	105,755
5 21[b]	17,703	36,493	54,196
5 22	66,297	115,579	181,876
5 23	10,923	11,025	21,948
5 24[b]	37,399	66,025	103,424
5 25	34,978	71,472	106,450
5 26[b]	25,870	74,138	100,008
5 27	24,482	47,754	72,236
5 28	18,151	103,187	121,338
5 29[b]	1,342	7,324	8,666
5 30	928	2,685	3,613
5 31	5,004	6,537	11,541
6 1	764	2,152	2,916
6 2	20,204	88,879	109,083
6 3	100,106	489,828	589,934
6 4	29,246	155,065	184,311
6 5	167,837	326,364	494,201
6 6	121,638	413,217	534,855
6 7	21,441	141,180	162,621
6 8[b]	40,282	94,728	135,010
6 9	15,515	44,311	59,826
6 10	2,619	6,889	9,508
6 11[b]	5,771	935	6,706
6 12[b]	3,510	17,978	21,488
6 13	2,134	5,938	8,072
Total	871,506	2,428,359	3,299,865
Percent	26.41	73.59	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Interpolated data for 0800-2200 hours on 21 May, 1200-1100 on 24 May, 0100-1100 on 26 May, 1800-2100 on 29 May, 1200-1100 on 8 June, 2100-1100 on 11 June, and 1600-0700 on 12 June.

Table 22. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Ugashik River, 1987.

Date[a]	Age I			Age II			Age III			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 17	19,088	21.36	19,088	70,277	78.64	70,277	0	.00	0	89,365	89,365
5 18	99,709	21.36	118,797	367,095	78.64	437,372	0	.00	0	466,804	556,169
5 19	24,096	18.26	142,893	107,865	81.74	545,237	0	.00	0	131,961	688,130
5 20	175,007	21.54	317,900	637,467	78.46	1,182,704	0	.00	0	812,474	1,500,604
5 21	80,339	19.87	398,239	323,987	80.13	1,506,691	0	.00	0	404,326	1,904,930
5 22	569,780	37.15	968,019	963,949	62.85	2,470,640	0	.00	0	1,533,729	3,438,659
5 23	52,543	32.01	1,020,562	111,604	67.99	2,582,244	0	.00	0	164,147	3,602,806
5 24	128,873	17.92	1,149,435	590,285	82.08	3,172,529	0	.00	0	719,158	4,321,964
5 25	208,905	26.19	1,358,340	588,747	73.81	3,761,276	0	.00	0	797,652	5,119,616
5 26	104,903	15.93	1,463,243	553,626	84.07	4,314,902	0	.00	0	658,529	5,778,145
5 27	75,559	15.93	1,538,802	398,764	84.07	4,713,666	0	.00	0	474,323	6,252,468
5 28	126,601	15.93	1,665,403	668,133	84.07	5,381,799	0	.00	0	794,734	7,047,202
5 29	4,624	8.56	1,670,027	49,398	91.44	5,431,197	0	.00	0	54,022	7,101,224
5 30	575	2.27	1,670,602	24,777	97.73	5,455,974	0	.00	0	25,352	7,126,576
5 31	1,770	2.27	1,672,372	76,237	97.73	5,532,211	0	.00	0	78,007	7,204,583
6 1	464	2.27	1,672,836	19,978	97.73	5,552,189	0	.00	0	20,442	7,225,025
6 2	17,605	2.27	1,690,441	757,986	97.73	6,310,175	0	.00	0	775,591	8,000,616
6 3	204,171	4.60	1,894,612	4,234,341	95.40	10,544,516	0	.00	0	4,438,512	12,439,128
6 4	63,985	4.60	1,958,597	1,327,008	95.40	11,871,524	0	.00	0	1,390,993	13,830,121
6 5	871,846	20.52	2,830,443	3,376,916	79.48	15,248,440	0	.00	0	4,248,762	18,078,883
6 6	1,302,387	26.34	4,132,830	3,642,134	73.66	18,890,574	0	.00	0	4,944,521	23,023,404
6 7	404,061	26.34	4,536,891	1,129,959	73.66	20,020,533	0	.00	0	1,534,020	24,557,424
6 8	476,024	35.56	5,012,915	862,627	64.44	20,883,160	0	.00	0	1,338,651	25,896,075
6 9	227,741	38.12	5,240,656	369,691	61.88	21,252,851	0	.00	0	597,432	26,493,507
6 10	46,166	48.74	5,286,822	48,193	50.88	21,301,044	350	.37	350	94,709	26,588,216
6 11	29,076	48.74	5,315,898	30,353	50.88	21,331,397	220	.37	570	59,649	26,647,865
6 12	106,611	48.74	5,422,509	111,292	50.88	21,442,689	809	.37	1,379	218,712	26,866,577
6 13	39,312	48.74	5,461,821	41,038	50.08	21,483,727	298	.37	1,677	80,648	26,947,225
	5,461,821	20.27		21,483,727	79.73		1,677	.00		26,947,225	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 23. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt in the Ugashik River, 1987.

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
5 17	9.7	4.3
5 18	9.7	4.3
5 19	10.1	4.1
5 20	9.7	4.3
5 21	10.0	4.1
5 22	8.9	4.7
5 23	10.0	4.2
5 24	10.8	3.8
5 25	10.0	4.1
5 26	11.4	3.6
5 27	11.4	3.6
5 28	11.4	3.6
5 29	12.0	3.5
5 30	12.3	3.4
5 31	12.3	3.4
6 1	12.3	3.4
6 2	12.3	3.4
6 3	11.7	3.6
6 4	11.7	3.6
6 5	9.9	4.2
6 6	9.4	4.4
6 7	9.4	4.4
6 8	8.7	4.8
6 9	8.7	4.8
6 10	8.7	4.8
6 11	8.7	4.8
6 12	8.7	4.8
6 13	8.7	4.8

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 24. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1979-85 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1979	1,700,904	-	-	0	-	
1980	3,321,384	-	12,736,379	26,384	-	
1981	1,326,762	31,297,432 (27)	82,656,993 (73)	0	113,954,425	85.89
1982	1,157,526	75,491,249 (78)	21,407,762 (22)	0	96,899,011	83.71
1983	1,000,614	12,693,628 (46)	15,186,101 (54)	1,677	27,881,406	27.86
1984	1,241,418	37,890,152 (64)	21,483,727 (36)		59,373,879	47.83[a]
1985	998,232	5,461,821				

[a] Preliminary, age-III outmigration in 1988 may increase this total.

Table 25. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival for 1979-85 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Age I			Age II			Age III		
		Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1979	1,700,904	-	3,963,182		-	2,004,153		0	0	
1980	3,321,384	-	3,463,594		12,736,379	4,193,843	0.33	26,384	2,627	0.10
1981	1,326,762	31,297,432	4,171,203	0.13	82,656,993	3,173,571	0.04	0	1,679	0.00
1982	1,157,526	75,491,249	1,132,251	0.02	21,407,762	1,336,523	0.06	0	0	0.00[b]
1983	1,000,614	12,693,628	984,238	0.08	15,186,101	636,681	0.04[b]	1,677	0	0.00[b]
1984	1,241,418	37,890,152	470,307	0.01[b]	21,483,727	53,862	0.00[b]			
1985	998,232	5,461,821	506	0.00[b]						

[a] Includes estimates of returns through 1988.

[b] Future adult returns will increase these values.

Table 26. Mean fork length and weight of sockeye salmon smolt captured in fyke nets in the Ugashik River, 1987.

	Age I					Age II					Age III				
Date[a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 18	94	11.2	7.6	3.36	20	105	22.2	9.8	5.82	79	--	--	--	--	0
5 19	93	8.4	7.3	1.19	10	108	19.2	11.1	6.56	85	--	--	--	--	0
5 20	92	9.2	6.8	2.00	8	105	20.8	10.0	5.61	75	--	--	--	--	0
5 21	95	9.2	7.5	2.42	8	106	15.9	10.4	4.99	63	--	--	--	--	0
5 22	92	9.5	7.0	2.30	31	104	16.9	9.8	5.05	69	--	--	--	--	0
5 23	93	19.3	8.2	4.32	19	109	25.5	12.1	7.75	81	--	--	--	--	0
5 24	96	15.4	7.3	3.25	17	110	19.5	11.1	6.16	81	--	--	--	--	0
5 25	93	13.0	7.4	3.63	20	110	21.6	11.3	6.36	81	--	--	--	--	0
5 28	96	14.7	9.4	4.68	14	110	23.0	12.5	7.59	180	--	--	--	--	0
5 29	96	11.2	9.2	3.98	12	108	17.7	12.6	5.83	75	--	--	--	--	0
5 30	101	.0	10.6	.00	1	112	17.4	14.7	6.47	38	--	--	--	--	0
5 31	--	--	--	--	0	112	15.7	14.5	6.29	99	--	--	--	--	0
6 2	99	.0	9.6	.00	1	111	13.4	13.0	4.11	99	--	--	--	--	0
6 4	105	5.4	10.5	2.77	3	111	19.0	11.7	6.18	97	--	--	--	--	0
6 5	95	13.0	7.5	2.93	29	107	17.9	10.5	5.82	171	--	--	--	--	0
6 7	92	14.0	7.3	3.51	45	103	15.0	10.0	4.61	54	--	--	--	--	0
6 8	89	14.7	6.3	3.20	72	101	10.6	9.2	2.84	30	--	--	--	--	0
6 9	92	14.3	6.7	3.19	75	103	18.9	9.5	5.60	124	--	--	--	--	0
6 10	88	11.4	7.6	2.59	77	96	12.0	8.8	3.10	23	--	--	--	--	0
6 12	90	16.5	6.8	3.89	66	101	19.5	9.4	6.64	57	138	.0	24.1	.00	1
Totals					528					1,661					1
Means	94		7.9			107		11.1			138		24.1		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 27. Mean fork length and weight of sockeye salmon smolt sampled from the Ugashik River, 1958-87.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		Age III		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1958	-	-	93	6.4	112	11.7	-	-	Pella and Jaenicke (1978)
1959	-	-	90	6.1	120	13.5	-	-	"
1960	-	-	90	6.6	104	11.0	-	-	"
1961	-	-	90	6.7	112	12.2	-	-	"
1962	12 May-28 June	1,070	88	6.1	112	12.3	-	-	Jaenicke (1963)
1963	5 May-26 June	921	90	6.1	104	9.6	-	-	Nelson and Jaenicke (1965)
1964	15 May-20 June	4,042	92	6.9	118	12.7	-	-	Nelson (1965)
1965	13 May-20 June	3,296	94	6.9	114	12.5	-	-	Nelson (1966)
1967	15 May-12 June	966	88	6.0	113	12.2	-	-	Nelson (1969)
1968	13 May-24 June	6,727	93	6.5	113	10.7	-	-	Siedelman (1969)
1969	23 May- 6 June	567	97	7.5	121	14.5	-	-	Schroeder (1972a)
1970	15 May-10 June	907	97	7.7	125	15.9	-	-	Schroeder (1972b)
1972	28 May-20 June	615	81	5.0	112	11.2	129	14.3	Schroeder (1974a)
1973	17 May-12 June	1,189	93	7.2	113	11.9	132	20.1	Schroeder (1974b)
1974	17 May-17 June	355	94	7.4	119	13.6	-	-	Schroeder (1975)
1975	3-13 June	-	96	7.2	116	13.0	125	16.7	Sanders (1976)
1982	6- 8 June	512	88	6.3	113	13.0	138	22.5	Eggers (1984)
1983	21 May-16 June	9,502	89	7.6	111	13.2	-	-	Fried et al. (1987)
1984	23 May-16 June	4,810	87	6.8	102	10.3	103	11.7	Fried et al. (1986)
1985	22 May-17 June	3,473	94	8.3	107	11.8	-	-	Bue (1986)
1986	21 May-14 June	1,555	87	5.8	114	10.9	-	-	Bue et al. (1988)
			—	—	—	—	—	—	
		Mean	91	6.7	113	12.3	125	17.1	
1987	18 May-12 June	2,190	94	7.9	107	11.1	138	24.1	

Table 28. Mean fork length and estimated weight, by estimated age of sockeye salmon smolt length frequencies in the Ugashik River, 1987.

	Estimated Age I				Estimated Age II			
Date[a]	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5 18[b]	93	11.1	7.4	84	104	19.8	10.3	258
5 19	91	17.2	6.9	114	106	24.4	10.8	396
5 20	91	16.7	7.0	134	105	23.8	10.4	339
5 21	91	14.8	7.0	107	106	26.0	10.9	319
5 22	90	24.5	6.7	258	104	25.2	10.1	340
5 23	91	13.2	6.9	117	108	23.3	11.3	183
5 24	92	12.7	7.2	71	109	29.1	11.9	320
5 25	90	19.2	6.8	190	107	28.3	11.2	455
5 28	92	13.0	7.2	159	111	40.9	12.6	849
5 29	93	6.3	7.4	15	112	29.2	12.9	359
6 1	--	--	--	0	110	13.8	12.0	79
6 2	95	1.8	7.9	4	109	25.0	11.8	599
6 4	94	7.3	7.6	17	110	30.7	12.1	628
6 5	90	21.0	6.9	290	106	26.1	10.6	934
6 7[c]	91	12.0	7.1	142	105	26.3	10.1	467
6 8	89	19.2	6.7	218	103	22.3	9.7	396
6 9	89	23.5	6.8	507	104	29.8	9.8	762
6 10	89	9.0	6.7	31	104	15.6	9.8	54
6 12	88	24.3	6.5	330	105	36.3	10.2	307
Totals				2,788				8,044
Means	91		7.0		107		11.0	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Length-weight parameters by age group and discriminating length used to separate ages for 18 May through 6 June were:
age I a= -10.25 b= 2.70 r^2= .72 n= 182
age II a= -11.94 b= 3.07 r^2= .78 n= 1325
discriminating length = 97.88

[c] Length-weight parameters by age group and discriminating length used to separate ages for 7 June through 14 June were:
age I a= - 9.20 b= 2.47 r^2= .60 n= 334
age II a= - 9.21 b= 2.47 r^2= .70 n= 287
discriminating length = 96.12

Table 29. Climatological and hydrological observations made at sockeye salmon smolt counting site for the Ugashik River, 1987.

Date	Cloud Cover[a]		Wind Velocity (km/hr)		Air Temp. (°C)		Water Temp. (°C)		Water Color
	0800 hours	2000 hours	0800 hours	2000 hours	Min.	Max.	0800 hours	2000 hours	
5 18	2	2	5 ESE	5 SSW	4.0	12.0	5.5	5.5	clear
5 19	3	4	5 E	8 E	3.0	7.0	6.5	6.5	clear
5 20	1	3	5 E	calm	3.0	6.0	5.5	-	clear
5 21	3	3	25 SE	18 SE	2.0	18.0	4.5	5.5	clear
5 22	4	4	calm	1-2 SE	5.0	13.5	5.0	5.0	clear
5 23	4	1	5-10 W	2-3 SW	4.0	7.0	5.5	5.0	clear
5 24	4	4	0-5 E	25 ESE	2.5	7.0	5.0	7.0	clear
5 25	3	4	5-10 E	10 SE	6.0	8.5	6.0	6.5	clear
5 26	3	4	10 SW	25 S	2.0	8.0	5.0	4.5	clear
5 27	3	3	0-5 S	1-3 SW	2.0	5.5	4.0	4.0	clear
5 28	2	3	calm	5 W	3.0	12.5	5.0	6.0	clear
5 29	4	4	0-5 W	10-15 W	6.0	11.5	5.0	5.0	clear
5 30	4	4	5 W	1-2 W	3.5	14.0	5.0	5.0	clear
5 31	4	4	10-15 S	5-10 SW	3.0	6.5	4.5	-	clear
6 1	4	4	10 SW	5 SW	2.0	6.5	4.0	4.0	clear
6 2	4	2	calm	calm	2.0	8.0	4.0	5.0	clear
6 3	4	-	calm	6 SW	4.0	12.0	4.5	8.0	clear
6 4	1	3	calm	5-10 ESE	2.5	17.0	6.5	8.5	clear
6 5	4	4	calm	5 W	7.0	12.0	7.5	6.0	clear
6 6	2	2	calm	0-5 SE	5.0	8.0	9.0	6.0	clear
6 7	3	-	-	3 W	-	-	6.0	-	clear
6 8	2	4	0-5 SE	25-30 SE	3.5	14.0	8.0	7.5	clear
6 9	4	3	0-5 SE	10 SE	5.0	11.5	8.5	7.0	clear
6 10	4	2	0-5 SE	calm	4.0	18.0	8.5	7.0	clear
6 11	3	4	0-5 ESE	-	4.0	17.0	6.5	6.5	clear
6 12	4	4	7-15 SSW	10-15 SSW	4.5	10.0	6.5	6.0	clear
6 13	4	3	7 SW	5 W	3.5	11.0	6.0	5.0	clear
6 14	4	4	-	5 W	2.0	7.5	5.5	5.5	clear

[a] 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 30. Water temperatures at sockeye salmon smolt counting site for the Ugashik River, 1983-87.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	Reference
1983	23 May-11 June	6.0	8.5	7.3	Fried et al. (1987)
1984	20 May-17 June	4.8	8.5	6.3	Fried et al. (1986)
1985	17 May- 9 June	-1.0	7.0	4.3	Bue (1986)
1986	23 May-28 June	2.0	7.0	5.6	Bue et al. (1988)
	Mean	3.0	7.8	5.9	
1987	17 May-13 June	4.0	9.0	5.9	

Table 31. Sonar counts recorded from four arrays, each with 10 transducers at the sockeye salmon smolt counting site on the Wood River, 1987.

Date[a]	Sonar Counts				
	Transducer Array				
	I	II	III	IV	Total
5 24	31	80	18	14	143
5 25	19	60	50	110	239
5 26	10	16	12	128	166
5 27	103	1,088	814	314	2,319
5 28	535	836	564	140	2,075
5 29	495	1,378	550	244	2,667
5 30	984	2,162	784	640	4,570
5 31	864	2,662	948	740	5,214
6 1	421	1,470	458	503	2,852
6 2	384	766	284	350	1,784
6 3	642	2,174	1,278	408	4,502
6 4	3,797	2,576	1,630	1,516	9,519
6 5	1,190	3,253	2,048	1,424	7,915
6 6	3,202	2,914	1,184	1,312	8,612
6 7	3,119	2,200	2,022	1,040	8,381
6 8	1,774	2,241	1,290	2,984	8,289
6 9	4,442	3,737	2,498	862	11,539
6 10	2,051	1,734	1,222	1,420	6,427
6 11	1,053	2,447	1,664	1,836	7,000
6 12	12,882	23,977	5,780	2,636	45,275
6 13	2,783	4,980	3,768	2,162	13,693
6 14	1,081	2,708	1,768	1,612	7,169
6 15	1,010	1,477	1,060	1,412	4,959
6 16	1,860	2,023	1,480	832	6,195
6 17	674	1,125	2,032	854	4,685
6 18	1,570	4,063	3,110	3,540	12,283
6 19	4,441	8,496	3,822	1,518	18,277
6 20	5,173	9,512	2,988	1,298	18,971
6 21	1,432	2,058	1,876	1,056	6,422
6 22	901	2,192	2,244	1,395	6,732
6 23	931	2,412	1,318	1,486	6,147
6 24	8,526	5,956	2,202	2,364	19,048
6 25	19,597	8,552	4,696	3,204	36,049

-Continued-

Table 31. (p 2 of 3).

Date[a]	Sonar Counts				
	Transducer Array				
	I	II	III	IV	Total
6 26	8,729	7,861	2,696	3,294	22,580
6 27	2,321	3,490	4,204	3,850	13,865
6 28	5,035	9,886	3,802	2,042	20,765
6 29	2,564	4,228	3,463	2,683	12,938
6 30	3,605	3,047	3,767	3,164	13,583
7 1	2,532	2,903	2,906	3,096	11,437
7 2	8,211	3,254	2,461	2,331	16,257
7 3	15,008	2,718	2,044	1,720	21,490
7 4	10,955	1,092	912	1,740	14,699
7 5	12,536	909	544	784	14,773
7 6	7,335	5,207	1,288	4,208	18,038
7 7	5,945	4,315	1,848	1,414	13,522
7 8	2,422	3,908	1,512	3,044	10,886
7 9	8,526	8,660	1,690	4,994	23,870
7 10	6,157	5,843	2,082	5,169	19,251
7 11	10,709	12,943	3,026	3,020	29,698
7 12	4,874	6,092	1,472	2,113	14,551
7 13	4,395	3,574	4,274	2,940	15,183
7 14	8,520	5,819	3,679	2,710	20,728
7 15	3,046	1,921	1,495	1,773	8,235
7 16	1,217	1,770	459	1,680	5,126
7 17	1,791	3,917	22,410	4,140	32,258
7 18	1,012	1,815	863	861	4,551
7 19	895	949	781	1,224	3,849
7 20	1,026	1,451	985	1,863	5,325
7 21	970	2,681	1,615	2,689	7,955
7 22	2,002	5,755	7,291	3,385	18,433
7 23	7,013	9,018	3,970	2,860	22,861
7 24	10,965	9,950	3,353	2,281	26,549
7 25	4,537	8,926	2,425	2,078	17,966

-Continued-

Table 31. (p 3 of 3).

Date[a]	Sonar Counts: Transducer Array I	II	III	IV	Total
7 26	3,654	6,456	6,310	1,798	18,218
7 27	2,053	1,165	3,680	1,529	8,427
7 28	2,093	1,840	2,160	2,332	8,425
7 29	3,426	4,340	4,600	3,322	15,688
7 30	2,663	4,235	4,303	3,053	14,254
7 31	2,339	2,265	2,080	2,122	8,806
8 1	1,906	2,435	2,060	1,436	7,837
8 2	1,556	3,630	3,240	978	9,404
8 3	1,167	1,949	2,400	3,173	8,689
8 4	998	955	2,930	1,386	6,269
8 5	618	398	800	812	2,628
Total	275,303	286,895	185,342	142,445	889,985
Percent	30.93	32.24	20.83	16.01	100.00

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 32. Percentage of total unexpanded sonar counts recorded over each array, Wood River, 1975-87.

	Percentage of Sonar Counts				
	Transducer Array				
Year	I	II	III	IV	References
1975[a]	68.6	31.4	-	-	Krasnowski (1976)
1976	49.0	30.2	11.7	9.1	Krasnowski (1977)
1977	36.0	24.4	20.8	18.8	Newcome (1978)
1978	28.6	29.7	25.6	16.1	Clark and Robertson (1980)
1979	17.0	27.1	33.1	22.8	Bucher (1980)
1980	34.1	35.2	20.5	10.2	Bucher (1981)
1981	39.2	24.8	24.9	11.1	Bucher (1982)
1982	38.2	31.3	15.9	14.6	Bucher (1984)
1983	31.6	29.9	23.5	15.0	Bucher (1987)
1984	23.9	36.7	22.2	17.2	Bucher (1986)
1985	34.2	36.3	18.5	11.0	Bucher (1986)
1986	34.2	36.3	18.5	11.0	Bue et al. (1988)
Mean[b]	33.3	31.1	21.4	14.2	
1987	30.9	32.3	20.8	16.0	

[a] Only two transducer arrays used.

[b] Data for 1975 omitted.

Table 33. Velocity correction factors used at Wood River, 1987.

Date	Array I	Array II	Array III	Array IV
6 4	1.02	1.10	1.10	1.19
6 8	1.00	1.04	1.11	1.13
6 12	1.00	0.98	0.98	1.03
6 17	1.02	1.15	1.16	1.16
6 24	1.08	1.13	1.17	1.18
7 2	1.03	1.12	1.12	1.18
7 10	0.99	1.04	1.08	1.11
7 13	0.99	1.05	1.07	1.13
7 20	0.97	1.05	1.07	1.07
7 23	1.06	1.16	1.14	1.23
7 28	0.98	1.05	1.22	1.21
8 3	1.02	1.10	1.11	1.20

Table 34. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Wood River, 1987.

	Age I			Age II			Age III			All Ages	
Date[a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 24	4,754	93.82	4,754	313	6.18	313	0	.00	0	5,067	5,067
5 25	11,272	93.82	16,026	742	6.18	1,055	0	.00	0	12,014	17,081
5 26	9,709	93.82	25,735	639	6.18	1,694	0	.00	0	10,348	27,429
5 27	81,545	93.82	107,280	5,371	6.18	7,065	0	.00	0	86,916	114,345
5 28	68,102	93.82	175,382	4,485	6.18	11,550	0	.00	0	72,587	186,932
5 29	88,170	94.94	263,552	4,699	5.06	16,249	0	.00	0	92,869	279,801
5 30	159,289	94.94	422,841	8,489	5.06	24,738	0	.00	0	167,778	447,579
5 31	181,601	94.94	604,442	9,678	5.06	34,416	0	.00	0	191,279	638,858
6 1	102,056	94.94	706,498	5,439	5.06	39,855	0	.00	0	107,495	746,353
6 2	68,545	95.51	775,043	3,222	4.49	43,077	0	.00	0	71,767	818,120
6 3	155,627	95.51	930,670	7,316	4.49	50,393	0	.00	0	162,943	981,063
6 4	357,141	95.51	1,287,811	16,789	4.49	67,182	0	.00	0	373,930	1,354,993
6 5	258,615	89.49	1,546,426	30,372	10.51	97,554	0	.00	0	288,987	1,643,980
6 6	274,040	89.49	1,820,466	32,184	10.51	129,738	0	.00	0	306,224	1,950,204
6 7	262,129	89.49	2,082,595	30,785	10.51	160,523	0	.00	0	292,914	2,243,118
6 8	323,498	90.78	2,406,093	32,855	9.22	193,378	0	.00	0	356,353	2,599,471
6 9	346,635	90.78	2,752,728	35,205	9.22	228,583	0	.00	0	381,840	2,981,311
6 10	222,841	90.78	2,975,569	22,632	9.22	251,215	0	.00	0	245,473	3,226,784
6 11	254,573	88.52	3,230,142	33,015	11.48	284,230	0	.00	0	287,588	3,514,372
6 12	1,243,634	88.52	4,473,776	161,284	11.48	445,514	0	.00	0	1,404,918	4,919,290
6 13	420,449	88.52	4,894,225	54,527	11.48	500,041	0	.00	0	474,976	5,394,266
6 14	257,064	95.76	5,151,289	11,382	4.24	511,423	0	.00	0	268,446	5,662,712
6 15	188,784	95.76	5,340,073	8,358	4.24	519,781	0	.00	0	197,142	5,859,854
6 16	207,913	95.76	5,547,986	9,205	4.24	528,986	0	.00	0	217,118	6,076,972
6 17	180,004	94.50	5,727,990	10,476	5.50	539,462	0	.00	0	190,480	6,267,452
6 18	507,515	94.50	6,235,505	29,537	5.50	568,999	0	.00	0	537,052	6,804,504
6 19	618,459	94.50	6,853,964	35,995	5.50	604,994	0	.00	0	654,454	7,458,958
6 20	604,067	91.83	7,458,031	52,361	7.96	657,355	1,447	0.22	1,447	657,875	8,116,833
6 21	228,643	91.83	7,686,674	19,819	7.96	677,174	547	0.22	1,994	249,009	8,365,842
6 22	249,691	91.83	7,936,365	21,643	7.96	698,817	598	0.22	2,592	271,932	8,637,774

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Table 34. (p 2 of 3).

Date[a]	Age I Number	Age I Percent	Age I Cumulative Total	Age II Number	Age II Percent	Age II Cumulative Total	Age III Number	Age III Percent	Age III Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
6 23	224,034	90.28	8,160,399	24,120	9.72	722,937	0	.00	2,592	248,154	8,885,928
6 24	639,593	90.28	8,799,992	68,861	9.72	791,798	0	.00	2,592	708,454	9,594,382
6 25	1,182,345	90.28	9,982,337	127,297	9.72	919,095	0	.00	2,592	1,309,642	10,904,024
6 26	770,546	90.28	10,752,883	82,960	9.72	1,002,055	0	.00	2,592	853,506	11,757,530
6 27	574,686	94.40	11,327,569	34,091	5.60	1,036,146	0	.00	2,592	608,777	12,366,307
6 28	713,167	94.40	12,040,736	42,306	5.60	1,078,452	0	.00	2,592	755,473	13,121,780
6 29	501,192	94.40	12,541,928	29,731	5.60	1,108,183	0	.00	2,592	530,923	13,652,703
6 30	531,905	94.40	13,073,833	31,553	5.60	1,139,736	0	.00	2,592	563,458	14,216,161
7 1	460,063	94.40	13,533,896	27,291	5.60	1,167,027	0	.00	2,592	487,354	14,703,515
7 2	572,152	94.40	14,106,048	33,941	5.60	1,200,968	0	.00	2,592	606,093	15,309,608
7 3	712,139	94.40	14,818,187	42,245	5.60	1,243,213	0	.00	2,592	754,384	16,063,992
7 4	503,025	94.40	15,321,212	29,840	5.60	1,273,053	0	.00	2,592	532,865	16,596,857
7 5	472,641	94.40	15,793,853	28,038	5.60	1,301,091	0	.00	2,592	500,679	17,097,536
7 6	678,722	94.40	16,472,575	40,263	5.60	1,341,354	0	.00	2,592	718,985	17,816,521
7 7	450,511	94.40	16,923,086	26,725	5.60	1,368,079	0	.00	2,592	477,236	18,293,757
7 8	430,744	94.40	17,353,830	25,552	5.60	1,393,631	0	.00	2,592	456,296	18,750,053
7 9	883,315	94.40	18,237,145	52,400	5.60	1,446,031	0	.00	2,592	935,715	19,685,768
7 10	714,270	94.40	18,951,415	42,371	5.60	1,488,402	0	.00	2,592	756,641	20,442,409
7 11	913,497	93.60	19,864,912	62,461	6.40	1,550,863	0	.00	2,592	975,958	21,418,367
7 12	468,212	93.60	20,333,124	32,014	6.40	1,582,877	0	.00	2,592	500,226	21,918,593
7 13	530,929	94.82	20,864,053	29,004	5.18	1,611,881	0	.00	2,592	559,933	22,478,526
7 14	690,895	94.82	21,554,948	37,743	5.18	1,649,624	0	.00	2,592	728,638	23,207,164

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Table 34. (p 3 of 3).

Date[a]	Age I Number	Age I Percent	Age I Cumulative Total	Age II Number	Age II Percent	Age II Cumulative Total	Age III Number	Age III Percent	Age III Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
7 15	299,013	94.82	21,853,961	16,335	5.18	1,665,959	0	.00	2,592	315,348	23,522,512
7 16	170,783	91.36	22,024,744	16,151	8.64	1,682,110	0	.00	2,592	186,934	23,709,446
7 17	938,976	91.36	22,963,720	88,799	8.64	1,770,909	0	.00	2,592	1,027,775	24,737,221
7 18	133,894	91.36	23,097,614	12,662	8.64	1,783,571	0	.00	2,592	146,556	24,883,777
7 19	130,005	91.36	23,227,619	12,294	8.64	1,795,865	0	.00	2,592	142,299	25,026,076
7 20	177,772	91.36	23,405,391	16,812	8.64	1,812,677	0	.00	2,592	194,584	25,220,660
7 21	262,234	91.36	23,667,625	24,799	8.64	1,837,476	0	.00	2,592	287,033	25,507,693
7 22	486,363	92.89	24,153,988	37,227	7.11	1,874,703	0	.00	2,592	523,590	26,031,283
7 23	632,379	92.89	24,786,367	48,403	7.11	1,923,106	0	.00	2,592	680,782	26,712,065
7 24	703,229	92.89	25,489,596	53,826	7.11	1,976,932	0	.00	2,592	757,055	27,469,120
7 25	472,721	91.88	25,962,317	41,777	8.12	2,018,709	0	.00	2,592	514,498	27,983,618
7 26	483,755	91.88	26,446,072	42,752	8.12	2,061,461	0	.00	2,592	526,507	28,510,125
7 27	247,714	91.88	26,693,786	21,892	8.12	2,083,353	0	.00	2,592	269,606	28,779,731
7 28	265,880	91.88	26,959,666	23,497	8.12	2,106,850	0	.00	2,592	289,377	29,069,108
7 29	466,041	91.88	27,425,707	41,186	8.12	2,148,036	0	.00	2,592	507,227	29,576,335
7 30	394,940	89.58	27,820,647	45,939	10.42	2,193,975	0	.00	2,592	440,879	30,017,214
7 31	248,962	89.58	28,069,609	28,959	10.42	2,222,934	0	.00	2,592	277,921	30,295,135
8 1	209,346	89.58	28,278,955	24,351	10.42	2,247,285	0	.00	2,592	233,697	30,528,832
8 2	232,643	89.58	28,511,598	27,061	10.42	2,274,346	0	.00	2,592	259,704	30,788,536
8 3	272,534	89.58	28,784,132	31,701	10.42	2,306,047	0	.00	2,592	304,235	31,092,771
8 4	175,601	89.58	28,959,733	20,426	10.42	2,326,473	0	.00	2,592	196,027	31,288,798
8 5	79,526	89.58	29,039,259	9,250	10.42	2,335,723	0	.00	2,592	88,776	31,377,574
	29,039,259	92.55		2,335,723	7.44		2,592	.00		31,377,574	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 35. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt in the Wood River, 1987.

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
5 24	5.6	7.4
5 25	5.6	7.4
5 26	5.6	7.4
5 27	5.6	7.4
5 28	5.6	7.4
5 29	5.7	7.3
5 30	5.7	7.3
5 31	5.7	7.3
6 1	5.7	7.3
6 2	5.5	7.6
6 3	5.5	7.6
6 4	5.5	7.6
6 5	5.9	7.1
6 6	5.9	7.1
6 7	5.9	7.1
6 8	5.6	7.4
6 9	5.6	7.4
6 10	5.6	7.4
6 11	5.4	7.7
6 12	5.4	7.7
6 13	5.4	7.7
6 14	5.2	7.9
6 15	5.2	7.9
6 16	5.2	7.9
6 17	5.4	7.7
6 18	5.4	7.7
6 19	5.4	7.7
6 20	5.4	7.7
6 21	5.4	7.7
6 22	5.4	7.7
6 23	5.5	7.5
6 24	5.5	7.5
6 25	5.5	7.5
6 26	5.5	7.5
6 27	5.4	7.7
6 28	5.4	7.7
6 29	5.4	7.7
6 30	5.4	7.7

-Continued-

Table 35. (p 2 of 2).

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
7 1	5.4	7.7
7 2	5.4	7.7
7 3	5.4	7.7
7 4	5.4	7.7
7 5	5.4	7.7
7 6	5.4	7.7
7 7	5.4	7.7
7 8	5.4	7.7
7 9	5.4	7.7
7 10	5.4	7.7
7 11	5.5	7.6
7 12	5.5	7.6
7 13	5.5	7.5
7 14	5.5	7.5
7 15	5.5	7.5
7 16	6.3	6.6
7 17	6.3	6.6
7 18	6.3	6.6
7 19	6.3	6.6
7 20	6.3	6.6
7 21	6.3	6.6
7 22	7.1	5.8
7 23	7.1	5.8
7 24	7.1	5.8
7 25	7.3	5.7
7 26	7.3	5.7
7 27	7.3	5.7
7 28	7.3	5.7
7 29	7.3	5.7
7 30	7.6	5.4
7 31	7.6	5.4
8 1	7.6	5.4
8 2	7.6	5.4
8 3	7.6	5.4
8 4	7.6	5.4
8 5	7.6	5.4

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 36. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1972-85 brood years, Wood River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1972	430,602	-	5,900,000	0	-	-
1973	330,474	27,950,000 (85)	4,800,000 (15)	0	32,750,000	99.24
1974	1,708,836	101,400,000 (89)	12,550,000 (11)	0	113,950,000	66.64
1975	1,270,116	60,750,000 (88)	8,400,000 (12)	0	69,150,000	54.45
1976	817,008	46,600,000 (90)	5,127,868 (10)	0	51,727,868	63.31
1977	561,828	60,838,182 (97)	1,993,345 (3)	0	62,831,527	111.83
1978	2,267,238	46,302,587 (58)	33,196,940 (42)	0	79,499,527	35.06
1979	1,706,352	64,330,507 (92)	4,706,853 (8)	0	69,037,360	40.46
1980	2,969,040	32,354,984 (89)	4,133,901 (11)	0	36,488,885	12.29
1981	1,233,318	19,594,247 (93)	1,378,417 (7)	0	20,972,664	17.01
1982	976,470	22,332,474 (83)	4,692,859 (17)	0	27,025,333	27.68
1983	1,360,968	31,948,110 (98)	597,724 (2)	2,592	32,548,426	23.92
1984	1,002,792	27,466,684 (92)	2,335,723 (8)		29,802,407	29.72[a]
1985	939,000	29,039,259				

[a] Preliminary, age-III outmigration in 1988 may increase this total.

Table 37. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival, for 1972-85 brood years, Wood River.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1972	430,602	-	1,430,065		5,900,000	59,353	0.01
1973	330,474	27,950,000	1,364,992	0.05	4,800,000	118,476	0.02
1974	1,708,836	101,400,000	4,661,537	0.05	12,550,000	496,546	0.04
1975	1,270,116	60,750,000	3,617,378	0.06	8,400,000	1,141,143	0.14
1976	817,008	46,600,000	4,895,420	0.11	5,127,868	867,507	0.17
1977	561,828	60,838,182	3,399,952	0.06	1,993,345	116,606	0.06
1978	2,267,238	46,302,587	2,546,030	0.05	33,196,940	742,252	0.02
1979	1,706,352	64,330,507	4,497,413	0.07	4,706,853	46,750	0.01
1980	2,969,040	32,354,984	1,585,416	0.05	4,133,901	187,961	0.05
1981	1,233,318	19,594,247	1,815,951	0.09	1,378,417	179,333	0.13
1982	976,470	22,332,474	1,488,687	0.07	4,692,859	153,312	0.03
1983	1,360,968	31,948,110	3,210,835	0.10	597,724	21,339	0.04[b]
1984	1,002,792	27,466,684	544,918	0.02[b]	2,335,723	0	0.00[b]
1985	939,000	29,039,259	4,078	0.00[b]			

[a] Includes estimates of returns through 1988.

[b] Future adult returns will increase these values.

Table 38. Mean fork length and weight of sockeye salmon smolt captured in fyke nets in the Wood River, 1987.

Date[a]	Age I					Age II					Age III				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 26	87	8.6	5.3	2.04	24	107	3.0	9.3	.36	2	--	--	--	--	0
5 27	86	15.9	5.6	3.21	112	103	10.6	9.8	2.21	8	--	--	--	--	0
5 28	85	17.5	5.1	3.18	115	104	12.7	8.8	3.12	5	--	--	--	--	0
5 29	86	14.2	5.6	3.12	114	104	6.3	10.9	7.73	6	--	--	--	--	0
5 30	85	13.8	5.1	2.72	114	107	3.0	9.9	1.96	2	--	--	--	--	0
6 1	86	14.0	5.4	2.91	113	106	4.0	9.2	1.41	7	--	--	--	--	0
6 2	85	14.4	5.1	2.89	108	103	8.3	8.8	2.22	8	--	--	--	--	0
6 3	87	12.9	5.4	2.63	115	108	5.1	10.1	1.00	3	--	--	--	--	0
6 4	86	15.8	5.3	3.49	119	78	.0	3.6	.00	1	--	--	--	--	0
6 5	86	14.6	5.6	2.72	116	--	--	--	--	0	--	--	--	--	0
6 6	84	14.5	5.5	2.76	92	104	13.5	9.5	3.47	28	--	--	--	--	0
6 7	83	15.4	5.5	2.88	105	97	13.8	8.7	3.32	13	--	--	--	--	0
6 8	83	12.4	5.3	2.16	92	104	14.8	9.6	4.40	28	--	--	--	--	0
6 9	84	14.8	5.3	2.94	115	106	5.2	9.4	1.05	5	--	--	--	--	0
6 10	82	12.0	5.1	2.38	117	103	1.2	8.8	.12	2	--	--	--	--	0
6 11	82	11.7	4.8	2.13	111	98	13.8	7.8	3.23	6	--	--	--	--	0
6 12	84	11.8	5.1	2.55	94	101	16.6	8.0	3.96	26	--	--	--	--	0
6 13	84	9.1	4.9	1.88	31	102	10.7	8.5	2.54	4	--	--	--	--	0
6 14	83	13.5	5.0	2.91	114	102	9.7	8.6	1.90	4	--	--	--	--	0
6 15	84	14.0	5.1	2.80	113	107	5.7	9.3	2.14	6	--	--	--	--	0
6 16	83	9.5	4.9	1.89	118	98	.0	8.3	.00	1	--	--	--	--	0
6 17	83	12.5	5.1	2.42	114	100	9.5	7.9	1.54	4	--	--	--	--	0
6 18	83	12.0	5.1	2.54	117	96	4.8	7.1	.77	2	--	--	--	--	0
6 19	85	14.1	5.2	2.72	108	98	15.6	7.6	3.35	11	--	--	--	--	0
6 20	83	16.7	4.9	2.49	102	99	8.5	7.7	2.54	13	101	.0	8.1	.00	1
6 21	84	10.7	5.1	2.37	93	103	3.6	8.8	1.13	2	--	--	--	--	0
6 22	84	11.9	5.2	2.65	107	97	16.0	8.7	6.50	13	--	--	--	--	0
6 24	85	12.8	5.4	2.75	95	103	15.4	9.0	3.82	23	--	--	--	--	0
6 25	84	15.1	5.2	2.70	112	96	11.4	7.1	1.69	8	--	--	--	--	0
6 26	81	13.5	4.9	3.04	113	95	4.2	7.1	1.06	6	--	--	--	--	0
6 27	82	9.7	4.7	1.73	19	104	.6	9.4	.54	2	--	--	--	--	0
7 7	82	8.6	4.7	2.00	51	96	2.4	7.1	.77	2	--	--	--	--	0
7 8	85	7.2	5.3	1.58	10	--	--	--	--	0	--	--	--	--	0
7 9	85	10.7	5.6	2.80	112	95	11.9	7.8	2.30	8	--	--	--	--	0
7 10	85	16.3	5.7	3.39	111	100	11.3	8.8	2.46	7	--	--	--	--	0
7 11	83	17.3	5.1	3.51	223	99	15.1	8.6	3.56	17	--	--	--	--	0
7 12	85	15.4	5.4	3.51	77	103	6.3	7.9	.27	3	--	--	--	--	0
7 13	84	17.9	5.7	4.11	117	95	3.8	8.0	.59	3	--	--	--	--	0
7 14	84	12.4	5.1	2.68	72	93	6.2	7.0	1.43	6	--	--	--	--	0

-Continued-

Table 38 (p 2 of 2).

Date[a]	Age I					Age II					Age III				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
7 15	85	12.4	5.4	3.00	69	95	5.4	8.1	1.96	2	--	--	--	--	0
7 16	84	10.1	5.5	2.28	33	93	9.5	6.7	1.61	2	--	--	--	--	0
7 17	86	12.8	5.8	3.23	18	0	.0	.0	.00	0	--	--	--	--	0
7 19	88	15.6	6.3	3.67	105	96	9.7	8.2	2.49	15	--	--	--	--	0
7 20	90	13.6	6.9	3.20	44	100	5.9	9.6	1.84	2	--	--	--	--	0
7 21	92	11.3	7.3	2.77	40	96	7.6	8.1	2.12	11	--	--	--	--	0
7 22	91	14.3	7.4	3.73	88	95	6.1	7.7	1.47	5	--	--	--	--	0
7 23	93	12.8	7.6	3.50	108	101	13.0	9.8	5.67	12	--	--	--	--	0
7 24	90	12.9	7.0	3.37	117	99	6.6	9.0	.63	3	--	--	--	--	0
7 25	91	15.4	7.4	4.29	113	98	5.5	9.2	1.83	6	--	--	--	--	0
7 26	90	10.6	7.1	2.74	42	121	1.8	15.6	.71	2	--	--	--	--	0
7 27	91	9.5	7.3	2.17	11	102	.6	9.4	.42	2	--	--	--	--	0
7 28	94	15.9	8.1	5.23	67	101	6.6	10.5	2.49	5	--	--	--	--	0
7 29	91	11.6	7.2	2.98	20	96	7.1	7.6	1.07	2	--	--	--	--	0
7 30	94	9.5	8.2	2.22	11	103	4.1	10.6	1.42	3	--	--	--	--	0
7 31	95	7.4	8.9	2.00	18	98	6.1	8.8	1.09	5	--	--	--	--	0
8 1	93	9.8	8.1	2.75	38	101	.0	9.6	.00	1	--	--	--	--	0
8 2	94	13.3	7.9	3.20	30	98	3.8	9.1	.72	3	--	--	--	--	0
8 3	86	18.0	6.4	3.93	7	0	.0	.0	.00	0	--	--	--	--	0
Totals					4,884					376					1
Means	86		5.8			100		8.7			101		8.1		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 39. Age composition of total migration, and mean fork length and weight by age class, for sockeye salmon smolt in the Wood River, 1951-87.

Year of Migration	Age I Percent of Total Estimate	Age I Mean Length (mm)	Age I Mean Weight (g)	Age II Percent of Total Estimate	Age II Mean Length (mm)	Age II Mean Weight (g)	Total Estimate	References
1951[a]	80.0	91	-	20.0	-	-	-	Univ. Washington (unpub.)
1952	99.0	87	-	1.0	-	-	-	"
1953	95.3	86	-	4.7	103	-	-	"
1954	95.8	87	-	4.2	107	-	-	"
1955	98.0	85	-	2.0	102	-	-	"
1956	78.4	82	-	21.6	95	-	-	"
1957	80.7	77	-	19.3	93	-	-	"
1958	65.0	82	-	35.0	102	-	-	"
1959	93.5	88	-	6.5	105	-	-	"
1960	99.4	88	-	0.6	114	-	-	"
1961	93.0	82	-	7.0	102	-	-	Church (1963)
1962	86.0	80	-	14.0	98	-	-	Church and Nelson (1963)
1963	84.3	83	-	15.7	102	-	-	Nelson (1964)
1964	98.8	84	-	1.2	104	-	-	Nelson (1965)
1965	92.0	86	-	8.0	106	-	-	Nelson (1966)
1966	94.3	77	-	5.7	101	-	-	Siedelman (1967)
1975[b]	86.0	83	-	14.0	98	-	33,850,000	Krasnowski (1976)
1976	95.5	84	-	4.5	95	-	106,200,000	Krasnowski (1977)
1977	82.9	71	3.5	17.1	98	9.3	73,300,000	Newcome (1978)
1978	84.7	79	-	15.3	90	-	55,000,000	Clark and Robertson (1980)
1979	92.2	90	7.6	7.8	100	10.1	65,966,050	Bucher (1980)
1980	96.0	78	4.0	4.0	95	6.8	48,295,932	Bucher (1981)
1981	66.1	88	6.3	33.9	96	8.4	97,527,446	Bucher (1982)
1982	87.3	79	4.7	12.7	98	8.4	37,061,837	Bucher (1984)
1983	82.6	86	6.5	17.4	98	9.2	23,728,252	Bucher (1987)
1984	94.2	92	7.8	5.8	97	8.7	23,710,947	Bucher (1986)
1985	87.2	92	7.2	12.8	91	7.1	36,640,969	Bucher (1986)
1986	97.9	87	5.9	2.1	101	9.2	54,661,948	Bue et al. (1988)
	Mean	84	5.9		100	8.6		
1987	92.6	86	5.8	7.4	100	8.7	36,227,371	

[a] Fyke net catches used to index abundance of smolt, 1951-66.

[b] Sonar equipment used to estimate numbers of smolt, 1975-87.

Table 40. Estimated infection by the cestode *Triaenophorus crassus* of age-I and age-II sockeye salmon smolt by period in the Wood River, 1987.

Sample Period	Age I		Age II	
	Number Examined	Percent Infected	Number Examined	Percent Infected
5 27 - 5 31	483	38.3	23	78.3
6 1 - 6 5	579	47.7	21	47.6
6 6 - 6 10	522	53.8	78	80.8
6 11 - 6 15	471	41.4	45	57.8
6 16 - 6 20	568	41.5	31	71.0
6 21 - 6 27	541	46.4	53	52.8
7 7 - 7 11	404	36.1	23	56.5
7 12 - 7 16	444	44.8	25	44.0
7 17 - 7 22	240	39.6	30	33.3
7 23 - 7 27	470	25.5	29	27.6
7 28 - 8 4	202	56.9	21	47.6
5 27 - 8 4	4,924	42.6	379	57.8

Table 41. Infection of Wood River sockeye salmon smolt by the cestode *Triaenophorus crassus*, 1978-87.

Year	Percent Infected		References
	Age I	Age II	
1978	15.1	40.5	Clark and Robertson (1980)
1979	10.0	30.8	Bucher (1980)
1980	11.1	17.3	Bucher (1981)
1981	28.2	35.6	Bucher (1982)
1982	10.0	21.2	Bucher (1984)
1983	43.1	73.6	Bucher (1987)
1984	41.1	45.7	Bucher (1986)
1985	35.7	41.5	Bucher (1986)
1986	40.8	45.6	Bue et al. (1988)
Mean	26.1	39.1	
1987	42.6	57.8	

Table 42. Water temperatures and depths, at field camp site, head of Wood River (outlet of Lake Aleknagik), 1987.

	Mean Water Temp. (°C)	Water Depth (m)
5 23	6.0	0.49
5 24	6.5	0.57
5 25	6.5	0.60
5 26	4.5	0.72
5 27	4.5	0.79
5 28	4.0	0.82
5 29	4.0	0.87
5 30	4.5	0.90
5 31	4.5	0.93
6 1	4.8	0.96
6 2	4.5	0.99
6 3	4.5	1.02
6 4	4.8	1.06
6 5	5.0	1.08
6 6	5.3	1.13
6 7	4.8	1.16
6 8	4.5	1.20
6 9	4.8	1.24
6 10	4.8	1.29
6 11	5.0	1.32
6 12	5.0	1.37
6 13	5.0	1.39
6 14	6.3	1.40
6 15	5.8	1.40
6 16	5.3	1.41
6 17	5.5	1.43
6 18	5.8	1.46
6 19	5.5	1.48
6 20	5.8	1.48
6 21	6.0	1.45
6 22	5.3	1.43
6 23	5.3	1.46
6 24	5.8	1.48
6 25	5.3	1.50
6 26	5.8	1.51
6 27	5.5	1.54
6 28	5.8	1.60
6 29	5.5	1.74
6 30	5.0	1.87

-Continued-

Table 42. (p 2 of 2).

	Mean Water Temp. (°C)	Water Depth (m)
7 1	5.3	1.94
7 2	5.5	1.96
7 3	5.5	-
7 4	5.8	1.92
7 5	6.5	1.90
7 6	6.3	1.87
7 7	6.8	1.80
7 8	6.5	-
7 9	6.5	-
7 10	7.0	1.65
7 11	7.8	-
7 12	9.5	-
7 13	10.0	1.50
7 14	9.8	1.47
7 15	7.3	1.42
7 16	6.3	-
7 17	7.0	-
7 18	7.3	1.34
7 19	7.3	-
7 20	7.3	1.31
7 21	7.5	-
7 22	8.0	1.25
7 23	8.8	1.22
7 24	9.5	1.16
7 25	10.3	-
7 26	11.0	1.10
7 27	10.5	-
7 28	13.0	1.01
7 29	14.5	0.93
7 30	15.3	0.88
7 31	14.0	-
8 1	11.0	-
8 2	9.5	0.76
8 3	8.8	0.71
8 4	8.0	0.70
8 5	8.0	-

Table 43. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), 1975-87.

Year	Sample Period	Water Temperature (°C)			Water Depth (m)			References
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
1975	29 May-19 July	2.0	9.5	5.0	-0.24	0.57	0.37	Krasnowski (1976)
1976	9 June- 7 August	2.0	14.0	8.0	0.24	1.07	0.57	Krasnowski (1977)
1977	9 June- 8 August	4.5	15.5	9.0	-	-	1.52	Newcome (1978)
1978	28 May- 9 August	5.0	16.0	9.0	0.37	0.98	0.82	Clark and Robertson (1980)
1979	30 May- 2 August	4.5	16.0	9.0	0.33	1.46	0.93	Bucher (1980)
1980	30 May-15 August	4.5	18.0	9.0	0.34	1.65	1.07	Bucher (1981)
1981	27 May-13 August	5.4	17.5	11.4	0.03	1.21	0.55	Bucher (1982)
1982	27 May-10 August	2.2	12.0	6.4	0.46	1.62	1.17	Bucher (1984)
1983	28 May-26 July	4.4	12.8	8.7	0.46	1.19	0.90	Bucher (1987)
1984	22 May-27 July	4.4	16.7	10.8	-0.21	0.23	0.01	Bucher (1986)
1985	6 June- 8 August	2.2	10.6	6.3	0.43	1.40	0.99	Bucher (1986)
1986	23 May-17 July	3.0	10.5	6.1	-0.61	1.06	0.57	Bue et al. (1988)
	Mean	3.7	14.1	8.2	0.14	1.13	0.79	
1987	23 May- 5 August	4.0	16.0	6.8	0.49	1.96	1.27	

Table 44. Climatological and hydrological observations made at sockeye salmon smolt counting site for the Wood River, 1987.

Date	Cloud Cover[a]		Wind Velocity (km/hr)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Color
	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours		
5 23	4	3	-	-	-	7.0	6.0	6.0	trace	lt. brn.
5 24	3	4	-	5 E	-	7.0	8.0	5.0	trace	clear
5 25	4	4	5 E	5 E	-	6.0	8.0	5.0	19.81	clear
5 26	4	2	calm	0-5 W	-	7.0	4.0	5.0	5.08	clear
5 27	4	4	-	5 W	-	6.0	4.0	5.0	2.54	clear
5 28	4	2	-	5-10 W	-	9.0	4.0	4.0	1.27	clear
5 29	3	3	5 E	5-10 W	9.0	11.0	4.0	4.0	-	clear
5 30	1	3	8-10 NW	10-15 NW	8.0	12.0	4.0	5.0	-	clear
5 31	1	1	0-5 NW	10 W	7.0	14.0	4.0	5.0	-	clear
6 1	1	1	calm	10 NW	8.0	16.6	4.0	5.5	-	clear
6 2	3	3	calm	5 SE	9.0	11.0	4.0	5.0	-	clear
6 3	4	3	1-5 SE	0-5 SE	7.0	13.0	4.0	5.0	-	clear
6 4	1	4	1-3 NW	0-5 NW	6.0	13.0	4.5	5.0	-	clear
6 5	4	-	10 NW	-	10.0	21.0	4.5	5.5	trace	clear
6 6	4	4	-	calm	-	14.0	5.0	5.5	trace	clear
6 7	3	1	8 NW	10-30 SE	5.0	17.0	4.5	5.0	-	clear
6 8	2	4	5 SW	10-30 E	7.0	11.0	4.0	5.0	1.27	clear
6 9	4	3	8 SW	5 SW	9.0	14.0	4.5	5.0	4.57	clear
6 10	4	3	10 SW	10-15 W	4.5	17.5	4.5	5.0	trace	clear
6 11	2	3	5 SW	calm	5.5	15.0	4.5	5.5	trace	clear
6 12	2	-	5 NW	-	7.5	-	5.0	-	-	clear
6 13	1	-	0-5 NW	-	5.5	-	5.0	-	trace	clear
6 14	4	3	calm	-	8.5	17.0	5.5	7.0	trace	clear
6 15	4	4	calm	-	8.0	11.0	5.5	6.0	1.27	clear
6 16	4	4	20 SE	calm	9.0	11.0	5.0	5.5	trace	clear
6 17	4	3	10 NW	calm	10.5	11.0	5.0	6.0	-	clear
6 18	4	4	0-5 SE	calm	10.0	8.0	5.5	6.0	7.62	clear
6 19	4	4	0-5 SE	10 SE	8.5	8.0	5.5	5.5	2.54	clear
6 20	3	4	calm	5-8 NW	6.5	9.5	5.0	6.5	6.35	clear
6 21	4	4	5-10 NW	10 SE	10.5	15.5	6.0	6.0	2.54	clear
6 22	4	4	calm	20 SE	10.0	10.0	5.5	5.0	11.43	clear
6 23	4	4	20-35 SE	20 SE	7.5	10.5	5.0	5.5	1.27	clear
6 24	3	1	5-20 VAR	-	11.0	17.0	5.0	6.5	-	clear
6 25	2	-	15-20 E	-	9.0	-	5.0	5.5	-	clear
6 26	4	4	5-10 SE	-	7.5	11.0	5.5	6.0	12.70	clear
6 27	4	-	10 E	-	8.5	11.0	5.5	5.5	12.70	clear
6 28	4	4	5 E	10-15 E	9.0	10.5	6.0	5.5	16.26	clear
6 29	4	4	10-20 E	15-40 E	9.5	12.5	5.5	5.5	16.76	clear
6 30	4	4	5 E	15-25 E	12.5	-	5.0	5.0	7.11	clear

-Continued-

Table 44. (p 2 of 2).

Date	Cloud Cover[a] 0800 hours	Cloud Cover[a] 2000 hours	Wind Velocity (km/hr) 0800 hours	Wind Velocity (km/hr) 2000 hours	Air Temp. (°C) 0800 hours	Air Temp. (°C) 2000 hours	Water Temp. (°C) 0800 hours	Water Temp. (°C) 2000 hours	Precipitation (mm)	Water Color
7 1	4	4	5-10 E	-	12.0	8.5	5.0	5.5	7.11	clear
7 2	4	4	calm	-	8.0	8.0	5.5	5.5	4.06	clear
7 3	4	4	calm	-	6.0	8.0	5.5	5.5	2.03	clear
7 4	4	4	10-15 SE	-	9.0	10.0	5.5	6.0	trace	clear
7 5	2	3	0-5 S	-	14.0	13.0	6.5	6.5	-	clear
7 6	4	-	-	-	11.0	9.5	6.0	6.5	trace	clear
7 7	4	4	-	-	9.0	12.0	7.0	6.5	2.54	clear
7 8	4	-	-	-	10.0	-	6.5	-	-	clear
7 9	3	-	-	-	9.0	-	6.5	-	-	clear
7 10	3	3	-	calm	11.0	13.0	7.0	7.0	-	clear
7 11	3	2	0-5 NE	-	12.0	15.0	7.5	8.0	-	clear
7 12	2	-	-	-	12.0	-	8.0	11.0	-	clear
7 13	3	4	-	-	12.0	18.5	10.0	10.0	trace	clear
7 14	4	3	-	0-5 NW	13.0	18.0	10.0	9.5	trace	clear
7 15	4	4	-	-	11.0	14.0	7.0	7.5	10.16	clear
7 16	4	3	15-20 NW	-	10.0	13.0	6.5	6.0	13.97	clear
7 17	4	4	-	-	12.0	13.0	7.0	7.0	23.62	clear
7 18	5	4	calm	-	12.0	14.0	7.0	7.5	3.30	clear
7 19	4	4	calm	-	13.0	16.0	7.0	7.5	trace	clear
7 20	3	3	calm	-	11.5	12.0	7.0	7.5	trace	clear
7 21	4	4	calm	-	10.0	13.0	7.0	8.0	8.89	clear
7 22	4	4	-	-	10.0	12.0	8.0	8.0	5.33	clear
7 23	3	1	calm	-	9.0	20.0	8.0	9.5	trace	clear
7 24	4	3	calm	-	12.0	15.0	9.5	9.5	trace	clear
7 25	1	1	calm	calm	7.0	14.0	10.0	10.5	-	clear
7 26	1	1	calm	-	13.0	26.0	10.0	12.0	-	clear
7 27	1	1	calm	-	12.0	29.5	10.5	-	-	clear
7 28	1	1	calm	-	14.0	29.5	12.0	14.0	0.00	clear
7 29	2	2	calm	-	15.0	27.0	13.0	16.0	0.00	clear
7 30	2	2	calm	-	14.5	26.0	14.5	16.0	0.00	clear
7 31	5	2	calm	-	10.0	22.0	13.5	14.5	0.00	clear
8 1	4	2	calm	-	-	18.5	-	11.0	0.00	clear
8 2	4	4	5-10 SE	5-10 SE	13.0	14.0	9.5	9.5	trace	clear
8 3	4	4	5-10 SE	5-10 SE	11.5	13.0	8.5	9.0	trace	clear
8 4	4	4	20 SE	calm	11.0	11.0	8.0	8.0	11.43	clear
8 5	4	4	15 SE	8-10 E	10.0	10.0	8.0	8.0	41.91	clear

[a] 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 45. Sonar counts recorded from three arrays, each with 10 transducers at the sockeye salmon smolt counting site on the Nuyakuk River, 1987. Sonar counts not adjusted for false counts due to debris.

Date[a]	Transducer Array			Total
	Inshore	Center	Offshore	
5 28	22	1	28	51
5 29	30	54	36	120
5 30	174	50	126	350
5 31	91	144	49	284
6 1	222	262	145	629
6 2[b]	81	106	157	344
6 3	234	250	324	808
6 4	155	246	344	745
6 5	9,345	3,250	1,104	13,699
6 6	4,520	3,356	1,350	9,226
6 7	2,233	2,431	735	5,399
6 8	536	771	684	1,991
6 9	971	1,634	1,338	3,943
6 10	5,172	6,030	2,723	13,925
6 11	6,282	10,231	7,427	23,940
6 12	1,626	2,875	2,448	6,949
6 13	804	1,586	1,757	4,147
6 14	641	1,230	1,197	3,068
6 15	777	1,038	984	2,799
6 16	910	1,753	1,407	4,070
6 17	921	2,019	1,785	4,725
6 18	541	907	696	2,144
6 19	420	717	807	1,944
6 20	778	1,569	1,401	3,748

-Continued-

Table 45. (p 2 of 2).

Date[a]	Transducer Array			Total
	Inshore	Center	Offshore	
6 21	921	1,441	1,309	3,671
6 22[b]	797	1,214	914	2,925
6 23	1,437	2,483	1,467	5,387
6 24	1,053	1,680	1,116	3,849
6 25	606	921	596	2,123
6 26	694	966	839	2,499
6 27	1,013	1,981	1,155	4,149
6 28[b]	1,281	2,333	1,375	4,989
6 29[b]	1,550	2,686	1,595	5,831
6 30[b]	1,818	3,038	1,816	6,672
7 1	2,086	3,390	2,036	7,512
Total	50,742	64,643	43,270	158,655
Percent	31.98	40.74	27.27	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Interpolated data for 1200-2300 hours on 2 June, 2100 on 22 June, all hours on 28-30 June.

Table 46. Velocity correction factors used at Nuyakuk River, 1987.

Date	Center	Offshore
5 28	0.93	0.96
5 29	0.93	0.96
5 30	1.14	1.04
5 31	1.11	0.94
6 1	1.09	1.04
6 2	1.09	1.04
6 3	1.15	1.15
6 4	1.03	1.07
6 5	1.02	1.02
6 6	1.07	1.07
6 7	1.07	1.16
6 8	1.02	1.05
6 9	1.02	1.05
6 10	1.06	1.03
6 11	1.07	1.03
6 12	1.05	1.00
6 13	1.05	1.01
6 14	1.09	1.08
6 15	1.04	1.03
6 16	1.02	1.02
6 17	1.05	1.02
6 18	1.03	1.04
6 19	1.05	1.05
6 20	1.05	1.05
6 21	1.00	1.02
6 22	1.00	1.02
6 23	1.05	1.02
6 24	1.02	1.00
6 25	1.02	1.02
6 26	1.02	1.05
6 27	1.02	0.98
6 28	1.00	0.96
6 29	1.00	0.96
6 30	0.98	0.94
7 1	1.04	0.98

Table 47. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Nuyakuk River, 1987. Sonar counts not adjusted for false counts due to debris.

	Age I			Age II			All Ages	
Date[a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 28	2,440	93.10	2,440	180	6.90	180	2,620	2,620
5 29	4,749	93.10	7,189	352	6.90	532	5,101	7,721
5 30	15,682	93.10	22,871	1,162	6.90	1,694	16,844	24,565
5 31	10,449	93.10	33,320	774	6.90	2,468	11,223	35,788
6 1	25,413	93.10	58,733	1,883	6.90	4,351	27,296	63,084
6 2	16,209	93.10	74,942	1,201	6.90	5,552	17,410	80,494
6 3	39,656	93.10	114,598	2,939	6.90	8,491	42,595	123,089
6 4	34,807	93.10	149,405	2,579	6.90	11,070	37,386	160,475
6 5	460,430	93.10	609,835	34,124	6.90	45,194	494,554	655,029
6 6	376,770	98.62	986,605	5,272	1.38	50,466	382,042	1,037,071
6 7	226,766	98.64	1,213,371	3,126	1.36	53,592	229,892	1,266,963
6 8	96,392	98.45	1,309,763	1,517	1.55	55,109	97,909	1,364,872
6 9	212,240	99.31	1,522,003	1,474	.69	56,583	213,714	1,578,586
6 10	630,958	98.97	2,152,961	6,566	1.03	63,149	637,524	2,216,110
6 11	1,161,367	98.97	3,314,328	12,086	1.03	75,235	1,173,453	3,389,563
6 12	355,496	98.28	3,669,824	6,221	1.72	81,456	361,717	3,751,280
6 13	209,350	94.19	3,879,174	12,913	5.81	94,369	222,263	3,973,543
6 14	170,443	96.74	4,049,617	5,743	3.26	100,112	176,186	4,149,729
6 15	134,359	94.67	4,183,976	7,564	5.33	107,676	141,923	4,291,652
6 16	193,245	94.40	4,377,221	11,463	5.60	119,139	204,708	4,496,360
6 17	186,375	73.26	4,563,596	68,027	26.74	187,166	254,402	4,750,762
6 18	83,213	73.26	4,646,809	30,373	26.74	217,539	113,586	4,864,348
6 19	78,913	73.26	4,725,722	28,803	26.74	246,342	107,716	4,972,064
6 20	183,662	87.16	4,909,384	27,056	12.84	273,398	210,718	5,182,782
6 21	173,788	87.16	5,083,172	25,601	12.84	298,999	199,389	5,382,171
6 22	129,053	83.44	5,212,225	25,612	16.56	324,611	154,665	5,536,836
6 23	228,450	83.44	5,440,675	45,339	16.56	369,950	273,789	5,810,625
6 24	162,163	83.44	5,602,838	32,184	16.56	402,134	194,347	6,004,972
6 25	110,832	94.72	5,713,670	6,178	5.28	408,312	117,010	6,121,982
6 26	139,566	94.72	5,853,236	7,779	5.28	416,091	147,345	6,269,327
6 27	210,238	94.72	6,063,474	11,719	5.28	427,810	221,957	6,491,284
6 28	245,598	94.72	6,309,072	13,690	5.28	441,500	259,288	6,750,572
6 29	284,673	94.72	6,593,745	15,868	5.28	457,368	300,541	7,051,113
6 30	315,361	94.72	6,909,106	17,579	5.28	474,947	332,940	7,384,053
7 1	317,120	94.72	7,280,226	20,687	5.28	495,634	391,807	7,775,860
Total	7,280,226	93.63		495,634	6.37		7,775,860	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 48. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt in the Nuyakuk River, 1987.

Date[a]	Mean Weight of Smolt (g)	Smolt per Count
5 28	5.6	7.4
5 29	5.6	7.4
5 30	5.6	7.4
5 31	5.6	7.4
6 1	5.6	7.4
6 2	5.6	7.4
6 3	5.6	7.4
6 4	5.6	7.4
6 5	5.6	7.4
6 6	5.3	7.9
6 7	5.2	8.0
6 8	5.1	8.1
6 9	4.6	9.0
6 10	4.9	8.5
6 11	4.9	8.5
6 12	4.7	8.9
6 13	4.8	8.7
6 14	4.5	9.2
6 15	4.8	8.7
6 16	4.7	8.8
6 17	4.5	9.2
6 18	4.5	9.2
6 19	4.5	9.2
6 20	4.3	9.6
6 21	4.3	9.6
6 22	4.4	9.5
6 23	4.4	9.5
6 24	4.4	9.5
6 25	4.0	10.4
6 26	4.0	10.4
6 27	4.0	10.4
6 28	4.0	10.4
6 29	4.0	10.4
6 30	4.0	10.4
7 1	4.0	10.4

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 49. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1980-85 brood years, Nuyakuk River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1980	3,026,568	-	1,259,339	-	-
1981	834,204	28,875,158 (99)	89,911 (1)	28,965,069	34.72
1982	537,864	6,293,644 (89)	769,319 (11)	7,062,963	13.13
1983	318,606	22,596,725 (99)	172,411 (1)	22,769,136	71.46
1984	472,596	11,063,753 (96)	495,634 (4)	11,559,387	24.46
1985	429,162	7,280,226			

Table 50. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival for 1979-85 brood years, Nuyakuk River.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1980	3,026,568	-	643,982		1,259,339	212,695	0.17
1981	834,204	28,875,158	2,022,007	0.07	89,911	26,895	0.30
1982	537,864	6,293,644	667,401	0.11	769,319	5,745	0.01
1983	318,606	22,596,725	644,306	0.03	172,411	2,481	0.01[b]
1984	472,596	11,063,753	117,918	0.01[b]	495,634	0	0.00[b]
1985	429,162	7,280,226	0	0.00[b]			

[a] Includes estimates of returns through 1988.

[b] Future adult returns will increase these values.

Table 51. Mean fork length and weight of sockeye salmon smolt captured in fyke nets in the Nuyakuk River, 1987.

	Age I					Age II				
Date[a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std Error	Sample Size
5 29	83	10.0	5.4	1.78	7	--	--	--	--	0
6 2	84	8.6	5.4	1.94	46	100	6.7	9.4	.79	3
6 3	85	4.5	5.4	1.33	7	91	.0	6.4	.00	1
6 5	86	8.6	5.6	2.09	80	100	8.5	8.7	2.33	10
6 6	83	12.6	5.1	2.47	86	100	4.7	8.1	1.52	4
6 7	82	13.3	5.1	3.00	89	103	.0	8.7	.00	1
6 8	81	13.6	4.6	2.80	87	98	7.0	8.4	1.20	3
6 9	82	18.9	4.8	2.89	103	--	--	--	--	0
6 11	81	15.7	4.2	2.50	87	89	3.5	5.3	.22	3
6 12	77	18.2	3.6	2.43	82	88	4.8	5.2	1.20	8
6 13	77	14.3	3.8	2.38	65	89	6.8	5.4	1.29	25
6 14	74	13.4	3.3	1.91	77	89	9.8	5.4	1.86	13
6 15	76	13.4	3.5	1.90	64	89	7.3	5.5	1.39	26
6 16	76	15.4	3.6	2.14	61	89	11.6	5.2	1.64	27
6 17	74	8.1	3.5	1.10	25	87	3.6	5.1	.78	11
6 18	77	12.2	3.6	1.67	50	90	10.2	5.5	1.83	43
6 19	75	9.0	3.6	1.53	31	87	9.0	5.4	1.63	15
6 20	74	9.7	3.2	1.41	14	84	4.3	5.2	1.24	4
6 21	76	10.9	3.7	1.68	69	87	7.1	5.2	1.43	21
6 22	78	7.6	3.6	1.14	6	93	3.6	6.4	.18	2
6 23	74	7.0	3.4	1.13	17	87	8.6	5.3	.89	6
6 24	74	11.5	3.8	2.08	78	86	4.3	5.6	1.36	12
6 25	73	11.1	3.4	2.11	73	89	6.0	5.7	1.11	6
6 26	76	8.2	3.5	1.29	32	88	7.4	5.4	.84	5
6 27	73	9.6	3.3	1.67	12	--	--	--	--	0
Totals					1,348					249
Means	78		4.1			91		6.2		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 52. Mean fork length and weight by age class, for sockeye salmon smolt in the Nuyakuk River, 1978, 1982-1987.

Year of Migration	Sample Dates	Sample Size	Age I Mean Length (mm)	Age I Mean Weight (g)	Age II Mean Length (mm)	Age II Mean Weight (g)	References
1978	18-19 June	350	71	4.3	85	5.8	Huttunen (1980)
1982	15 June- 9 July	208	76	3.9	96	6.8	Minard (1984)
1983	27 May-30 June	1,847	75	4.3	91	6.6	Minard and Frederickson (1987)
1984	27 May-26 June	980	81	4.9	93	7.3	Minard and Frederickson (1986)
1985	24 May-28 June	1,479	85	5.5	89	6.6	Minard and Brandt (1986)
1986	24 May-27 June	1,840	81	4.7	91	6.3	Bue et al. (1988)
		Mean	78	4.6	91	6.6	
1987	29 May-27 June	1,597	78	4.1	91	6.2	

Table 53. Mean fork length and estimated weight, by estimated age of sockeye salmon smolt length frequencies in the Nuyakuk River, 1987.

	Estimated Age I				Estimated Age II			
Date[a]	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
6 5[b]	85	9.7	5.2	82	105	10.3	10.1	6
6 6	84	13.7	5.1	196	96	3.9	7.3	4
6 7	82	12.3	4.7	198	99	7.7	8.0	7
6 8	82	13.6	4.7	194	101	9.1	8.8	6
6 9	83	15.7	4.9	194	98	7.3	7.9	6
6 11	80	21.0	4.3	197	94	.0	6.6	3
6 12	77	22.0	3.9	198	97	1.2	7.4	2
6 13	77	23.7	3.9	186	97	7.0	7.4	8
6 14	74	19.5	3.5	138	93	.0	6.4	2
6 15[c]	78	23.6	4.1	196	94	4.1	6.8	5
6 16	77	23.0	3.9	185	96	5.5	7.2	4
6 18	75	9.5	3.5	9	91	1.9	5.7	3
6 21	75	11.8	3.5	121	88	6.2	5.3	16
6 24	75	14.8	3.5	168	87	7.2	5.2	32
Totals				2,262				104
Means	79		4.2		95		7.1	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Length-weight parameters by age group and discriminating length used to separate ages for 5 June through 14 June were:
age I a= -12.23 b= 3.12 r^2= .79 n= 739
age II a= -14.08 b= 3.51 r^2= .87 n= 58
discriminating length = 92.11

[c] Length-weight parameters by age group and discriminating length used to separate ages for 15 June through 27 June were:
age I a= - 9.29 b= 2.44 r^2= .57 n= 608
age II a= - 7.41 b= 2.03 r^2= .52 n= 190
discriminating length = 83.55

Table 54. Climatological and hydrological observations made at sockeye salmon smolt counting site for the Nuyakuk River, 1987.

Date	Cloud Cover[a]		Wind Velocity (km/hr)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Color
	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours	0800 hours	2000 hours		
5 29	3	3	calm	0-5 N	-	10.0	1.1	3.3	0.00	clear
5 30	1	2	calm	5-10 N	3.9	11.1	1.7	3.9	0.00	clear
5 31	1	1	0-5 N	5-10 W	10.0	13.3	2.8	4.2	0.00	clear
6 1	1	1	calm	0-5 NW	4.4	14.4	2.2	3.3	0.00	clear
6 2	4	3	calm	0-5 NW	5.0	11.1	0.6	2.2	0.00	clear
6 3	4	2	calm	0-5 NW	5.0	13.3	2.8	3.3	0.00	clear
6 4	1	2	0-5 VAR	0-5 NW	4.4	15.6	2.8	3.3	0.00	clear
6 5	4	2	0-5 NW	10-20 SE	8.9	16.7	2.8	3.9	5.08	clear
6 6	4	4	0-5 N	calm	7.8	12.2	3.9	3.3	trace	clear
6 7	1	2	calm	25-30 SE	8.3	12.8	3.9	3.9	5.08	clear
6 8	1	2	20 SE	25-50 SE	7.8	10.0	3.9	3.3	trace	clear
6 9	4	3	20-40 SE	0-5 NE	7.2	10.0	4.4	4.4	trace	clear
6 10	4	3	calm	5-10 N	4.4	12.2	4.4	4.4	5.08	murky
6 11	1	3	0-5 NW	calm	6.1	14.4	4.4	5.0	trace	murky
6 12	3	1	5-10 NW	calm	10.0	14.4	5.0	5.6	0.00	murky
6 13	1	4	calm	0-5 NW	7.8	12.8	5.0	5.6	6.35	murky
6 14	1	1	calm	0-5 NW	6.7	-	5.0	-	trace	clear
6 15	4	4	calm	5-10 SE	4.4	11.1	5.0	5.0	trace	clear
6 16	4	4	0-5 N	0-5 N	6.7	10.0	4.4	5.0	7.62	clear
6 17	4	3	calm	0-5 NW	8.3	12.2	4.4	5.0	6.35	clear
6 18	4	4	5-10 S	0-5 N	6.1	10.6	5.6	5.3	7.62	clear
6 19	4	3	0-5 SE	0-5 VAR	6.1	12.2	4.7	5.0	2.54	clear
6 20	4	4	calm	calm	5.0	10.0	4.7	5.0	2.54	clear

-Continued-

Table 54. (p 2 of 2).

Date	Cloud Cover[a] 0800 hours	Cloud Cover[a] 2000 hours	Wind Velocity (km/hr) 0800 hours	Wind Velocity (km/hr) 2000 hours	Air Temp. (°C) 0800 hours	Air Temp. (°C) 2000 hours	Water Temp. (°C) 0800 hours	Water Temp. (°C) 2000 hours	Precipitation (mm)	Water Color
6 21	4	2	calm	calm	8.9	14.4	5.0	5.6	3.81	clear
6 22	4	4	0-5 N	15-20 E	8.9	10.6	5.3	5.3	8.89	clear
6 23	4	4	30-40 SE	10-20 E	6.7	11.1	5.0	5.0	2.54	clear
6 24	3	3	0-5 N	10-20 E	11.1	10.0	5.0	5.0	trace	clear
6 25	2	2	5-10 E	25-30 SE	9.4	10.0	5.0	5.6	0.00	clear
6 26	4	4	5-10 SE	25-30 SE	7.8	7.2	5.0	5.3	5.08	clear
6 27	4	4	0-5 E	5-10 E	8.3	10.6	5.0	5.3	trace	clear
6 28	4	4	10-20 SE	10-20 SE	6.1	10.0	5.0	5.0	7.62	clear
6 29	3	4	30-50 SE	10-30 SE	10.0	7.8	5.0	6.1	15.24	clear
6 30	4	4	10-15 S	5-10 SE	7.8	10.6	6.9	8.1	4.06	murky
7 1	4	4	0-5 SE	0-5 SE	7.8	10.6	6.9	6.7	6.35	murky
7 2	4	3	calm	0-5 SE	7.8	12.8	6.7	5.6	trace	murky

[a] 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

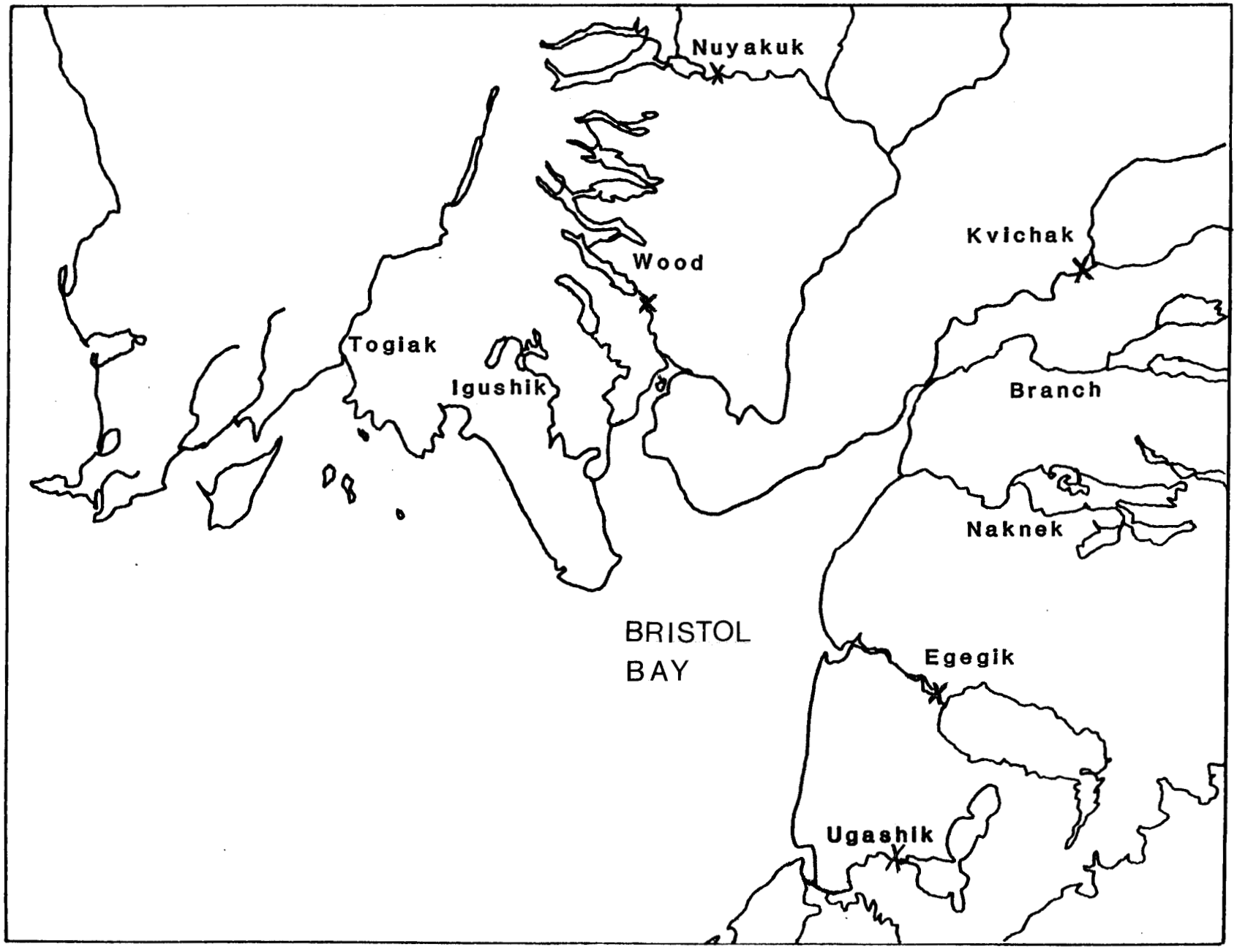

Figure 1. Bristol Bay management area showing major rivers and locations of sonar for smolt enumeration.

APPENDICES

Appendix A.1. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1980-84 brood years, Naknek River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
1978	813,378	-	-	0		
1979	925,362	-	12,898,936	23,256		
1980	2,644,698	115,624,396 (88)	16,497,326 (12)	594,898	132,716,620	50.18
1981	1,796,220	36,798,239 (43)	48,825,473 (57)	20,579	85,644,291	47.68
1982	1,155,552	32,139,569 (71)	13,370,305 (29)	37,647	45,547,521	39.42
1983	888,294	6,306,803 (25)	19,147,877 (75)		25,454,680	28.66
1984	1,242,474	22,143,831				

Appendix A.2. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival for 1978-85 brood years, Naknek River.

Brood Year	Total Spawning Escapement	Age I			Age II			Age III		
		Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1977	1,085,856	-	2,976,617		-	495,092		0	4,905	
1978	813,378	-	2,034,044		-	1,639,386		0	1,449	
1979	925,362	-	3,394,642		12,898,936	1,197.608	0.09	23,256	6,300	0.27
1980	2,644,698	115,624,396	2,193,821	0.02	16,497,326	2,037,353	0.12	594,898	62	0.00[b]
1981	1,796,220	36,798,239	3,377,713	0.09	48,825,473	1,417,740	0.03[b]	20,579	0	0.00[b]
1982	1,155,552	32,139,569	1,375,062	0.04[b]	13,370,305	651,757	0.05[b]	37,647	0	0.00[b]
1983	888,294	6,306,803	651,043	0.10[b]	19,147,877	345,206[b]	0.02[b]			
1984	1,242,474	22,143,831	472,349[b]	0.02[b]	-	22,918[b]				
1985	1,849,938	-	1,941[b]							

[a] Includes estimates of returns through 1988.

[b] Future adult returns will increase these values.

Appendix A.3. Sonar counts recorded from three arrays, each with 10 transducers at the sockeye salmon smolt counting site on the Nuyakuk River, 1987. Sonar counts reduced for estimated false counts from debris.

Date[a]	Transducer Array			Total
	Inshore	Center	Offshore	
5 28	22	1	28	51
5 29	30	54	36	120
5 30	174	50	126	350
5 31	91	144	49	284
6 1	222	262	145	629
6 2[b]	81	106	157	344
6 3	234	250	324	808
6 4	155	246	344	745
6 5	9,345	3,250	1,104	13,699
6 6	4,520	3,356	1,350	9,226
6 7	2,233	2,431	735	5,399
6 8	536	771	684	1,991
6 9	971	1,634	1,338	3,943
6 10	5,172	6,030	2,723	13,925
6 11	6,282	10,231	7,427	23,940
6 12	976	1,092	1,420	3,488
6 13	322	508	176	1,006
6 14	308	209	96	613
6 15	482	280	128	890
6 16	455	789	310	1,554
6 17	534	1,050	678	2,262
6 18	200	735	299	1,234
6 19	239	387	638	1,264
6 20	311	596	406	1,313

-Continued-

Appendix A.3. (p 2 of 2).

Date[a]	Transducer Array			Total
	Inshore	Center	Offshore	
6 21	378	476	681	1,535
6 22[b]	359	607	484	1,450
6 23	690	695	645	2,030
6 24	684	1,378	301	2,363
6 25	315	166	155	636
6 26	291	290	453	1,034
6 27	425	396	92	913
6 28[b]	412	432	166	1,010
6 29[b]	400	469	240	1,109
6 30[b]	387	505	313	1,205
7 1	375	542	387	1,304
Total	38,611	40,418	24,638	103,667
Percent	37.25	38.99	23.77	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Interpolated data for 1200-2300 hours on 2 June, 2100 on 22 June, and all hours on 28-30 June.

Appendix A.4. Daily number of sockeye salmon smolt migrating seaward estimated with a sonar unit in the Nuyakuk River, 1987. Sonar counts reduced for estimated false counts from debris.

	Age I			Age II			All Ages	
Date[a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5 28	2,440	93.10	2,440	180	6.90	180	2,620	2,620
5 29	4,749	93.10	7,189	352	6.90	532	5,101	7,721
5 30	15,682	93.10	22,871	1,162	6.90	1,694	16,844	24,565
5 31	10,449	93.10	33,320	774	6.90	2,468	11,223	35,788
6 1	25,413	93.10	58,733	1,883	6.90	4,351	27,296	63,084
6 2	16,209	93.10	74,942	1,201	6.90	5,552	17,410	80,494
6 3	39,656	93.10	114,598	2,939	6.90	8,491	42,595	123,089
6 4	34,807	93.10	149,405	2,579	6.90	11,070	37,386	160,475
6 5	460,430	93.10	609,835	34,124	6.90	45,194	494,554	655,029
6 6	376,770	98.62	986,605	5,272	1.38	50,466	382,042	1,037,071
6 7	226,766	98.64	1,213,371	3,126	1.36	53,592	229,892	1,266,963
6 8	96,392	98.45	1,309,763	1,517	1.55	55,109	97,909	1,364,872
6 9	212,240	99.31	1,522,003	1,474	0.69	56,583	213,714	1,578,586
6 10	630,958	98.97	2,152,961	6,566	1.03	63,149	637,524	2,216,110
6 11	1,161,367	98.97	3,314,328	12,086	1.03	75,235	1,173,453	3,389,563
6 12	184,866	98.28	3,499,194	3,235	1.72	78,470	188,101	3,577,664
6 13	42,450	94.19	3,541,644	2,618	5.81	81,088	45,068	3,622,732
6 14	28,183	96.74	3,569,827	949	3.26	82,037	29,132	3,651,864
6 15	36,328	94.67	3,606,155	2,045	5.33	84,082	38,373	3,690,237
6 16	66,060	94.40	3,672,215	3,918	5.60	88,000	69,978	3,760,215
6 17	84,449	73.26	3,756,664	30,824	26.74	118,824	115,273	3,875,488
6 18	44,960	73.26	3,801,624	16,410	26.74	135,234	61,370	3,936,858
6 19	54,450	73.26	3,856,074	19,874	26.74	155,108	74,324	4,011,182
6 20	61,425	87.16	3,917,499	9,048	12.84	164,156	70,473	4,081,655
6 21	77,262	87.16	3,994,761	11,381	12.84	175,537	88,643	4,170,298
6 22	64,987	83.44	4,059,748	12,897	16.56	188,434	77,884	4,248,182
6 23	88,891	83.44	4,148,639	17,641	16.56	206,075	106,532	4,354,714
6 24	87,808	83.44	4,236,447	17,426	16.56	223,501	105,234	4,459,948
6 25	32,377	94.72	4,268,824	1,804	5.28	225,305	34,181	4,494,129
6 26	62,201	94.72	4,331,025	3,467	5.28	228,772	65,668	4,559,797
6 27	40,626	94.72	4,371,651	2,264	5.28	231,036	42,890	4,602,687
6 28	46,080	94.72	4,417,731	2,568	5.28	233,604	48,648	4,651,335
6 29	52,130	94.72	4,469,861	2,905	5.28	236,509	55,035	4,706,370
6 30	56,588	94.72	4,526,449	3,154	5.28	239,663	59,742	4,766,112
7 1	65,572	94.72	4,592,021	3,655	5.28	243,318	69,227	4,835,339
	4,592,021	94.97		243,318	5.03		4,835,339	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.